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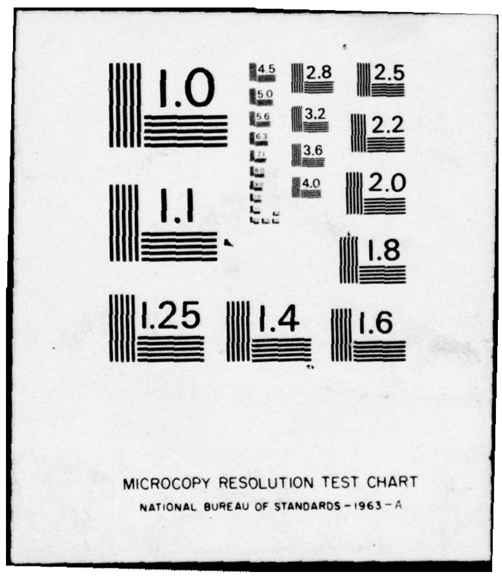
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Aviation Forecasts Fiscal Years 1977-1988

SEPTEMBER 1976

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA

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16. Abstract

This report contains the latest Federal Aviation Administration forecast of measures of workload and activity at towered airports, air route traffic control centers, and flight service stations for Fiscal Years 1977 to 1988. The forecasts were made for the four major users of the system; air carriers, air taxi, general aviation and the military. The report has been prepared to meet the budget and planning needs of the various offices and services of FAA for data concerning future trends in aviation activity.

This report reflects the impact on aviation activity of a continuing recovery from a recession with economic growth moderating in the long term. Based on these assumptions, aviation activity is forecast to increase by 30 percent at towered airports, 28 percent at air route traffic control centers and 38 percent in flight services performed by Fiscal Year 1981.

Of the users of the system, general aviation and air taxi will have the greatest percentage growth during the forecast years although in absolute terms the air taxi impact is relatively small. The air carriers will have a lower growth rate while military activity is expected to remain at its current levels throughout the forecast period. In absolute terms, general aviation will continue to increase its portion of all aviation activities so that by 1981 general aviation will account for 77 percent of total operations at towered airports, 32 percent of workload at air route traffic control centers and continue to increase its domination of flight services performed by the FAA.

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EXECUTIVE SUMMARY

This is the latest report in a series of forecasts of user demand for FAA services. The forecasts provide the support for agency budget requests and the basis for policy and plans development, as well as aviation activity information to the aviation community and to the general public.

The basic underlying assumptions for the 1977-88 forecasts include the following:

- Short-term optimism modified by a more cautious attitude over the long-term. The overall outlook is for moderate economic growth and declining, but still relatively high, unemployment with inflation rates of about 6 percent.
- The supply of energy and fuel will not significantly inhibit economic or aviation growth, although prices are expected to increase over the forecast period.

- The basic growth trends in the air carrier industry will continue. In the short-term it is expected that air traffic and airline revenues will improve in response to the general economic recovery.
- The economic outlook for the general aviation industry continues to be healthy.
- No operational constraints such as curfews are reflected.
- Military aviation activities were assumed to remain at current levels or slightly below.

The FAA provides the aviation community with three distinct operational services: air traffic control at selected airports; IFR en route traffic control; and flight services, including pilot briefings, flight plan filings, and aircraft contacts. These services are provided to four major categories of users: the air carriers, the air taxis, general aviation, and the military. Each category uses these services in different degrees. Because of the different relationships and growth trends among the four users and the three FAA services, there is no one workload measure, such as airport operations, or aviation activity series,

such as air carrier revenue passenger miles, which typifies the past trends or future outlook for all FAA services. There have been, and there will continue to be, different socioeconomic and political forces which drive the growth trends in each major user category.

Analysis of the three basic FAA operational services should properly begin with a breakdown or separation by user category. All of the forecasts included herein follow this approach. First, the underlying factors influencing the growth patterns of each major user are determined and forecast. Based on these trends and past relationships and through the use of econometric models, separate demand forecasts for FAA services are derived for each user category. The forecasts of total FAA operations and services reflect a summation of the individual forecasts of the four major users.

Total aircraft operations (take-offs and landings) at airports with FAA air traffic control towers are forecast to increase by 30 percent between Fiscal Years (FY) 1976 and 1981 and by 72 percent in the 12-year period ending in FY 1988. This growth will be dominated by the general aviation segment. General aviation operations accounted for 76 percent of the total in FY 1976. By FY 1981 general aviation operations will constitute 77 percent of total

operations. The FY 1988 estimate shows general aviation operations representing 79 percent of the total figure. In comparison, air carriers accounted for 15 percent of FY 1976 operations. By FY 1981 air carrier operations are expected to decline to 13 percent and by FY 1988 to 12 percent of total operations. Total instrument operations at the same towered airports are forecast to show an even greater growth than aircraft operations, rising 38 percent by 1981 and 76 percent by 1988.

IFR aircraft handled at FAA air route traffic control centers are expected to increase 28 percent and 64 percent by FY 1981 and 1988, respectively. Air carrier traffic accounts for about 52 percent of the current volume followed by general aviation at 25 percent, military at 17 percent, and air taxis at 6 percent. Except for military traffic, all users are forecast to show increases. The air carriers will increase 17 percent by FY 1981 and 44 percent by FY 1988. In the same time span, the number of general aviation IFR aircraft handled will rise 65 percent and 123 percent. General aviation aircraft handled will account for 34 percent of the total in FY 1988 compared with 25 percent today.

Flight services performed by the FAA, which include briefing pilots, filing flight plans, and contacting aircraft, are forecast to show the highest growth rate

of any of the FAA operational series. By FY 1981 flight services are expected to show a 38 percent increase, and by FY 1988 they should reach nearly twice the current level. As is the case with aircraft operations, general aviation flyers generate most of the activity for the flight services segment.

INTRODUCTION

This report contains the latest Federal Aviation Administration forecast of measures of workload and activity at towered airports, air route traffic control centers, and flight service stations for the period Fiscal Year (FY) 1977 to 1988. The forecasts were made for the four major users of the system; air carrier, air taxi, general aviation, and the military. The report has been prepared to meet the budget and planning needs of the various offices and services of FAA for data concerning future trends in aviation activity. In addition, the report serves as a valuable source of information to the aviation community and to the general public.

This publication is one of a series of specialized aviation forecast studies issued annually by the FAA Aviation Forecast Branch, Office of Aviation Policy. The series includes "Military Air Traffic Forecasts 1977-1988," "Terminal Area Forecast 1977-1988," and "IFR Aircraft Handled Forecast by Air Route Traffic Control Centers 1977-1988." Copies of these reports are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

This year the report includes three long-term forecasts. A baseline forecast for 1977 through 1988 is presented on a year-by-year basis. In addition, a high and a low scenario, showing possible impacts of different economic conditions, are presented for FY 1988.

Two new forecasts have been added this year dealing with air cargo and the military fleet size. The air cargo forecast is for domestic and international revenue cargo ton-miles and revenue tons enplaned. The military forecast is for the number of aircraft stationed within the continental United States. The forecast is subdivided by engine type and by fixed-wing aircraft and helicopters.

Table A is presented as a general overview of this year's forecasts. In addition to providing a capsule version of the September 1976 forecast, Table A presents a comparison with last year's forecasts across the selected activity measures.

The decrease in total operations during the 1978-1982 period is attributable primarily to lower forecasts of local operations compared to those made in September 1975 due primarily to lower forecast of disposable income and student starts. Specifically, general aviation local operations are about 5 percent lower in 1978 and the discrepancy is somewhat greater in later years. Air carrier itinerant operations are also lower (6 to 7 percent in later years). The number of air taxi itinerant operations is higher in the present forecast than that shown in the September 1975 forecast.

Table A

FORECAST COMPARISONS

September 1976 versus September 1975

	Tower Operations (In millions)			Instrument Operations (In millions)		
	1975	1976	Percent Change	1975	1976	Percent Change
Actual						
1976		62.5			28.1	
Forecast						
1977*	65.9	66.6	+ 1.1	28.6	30.9	+ 8.0
1978*	71.6	69.8	+ 2.5	31.1	33.3	+ 7.1
1979*	77.8	72.8	- 6.4	33.6	35.0	+ 4.2
1980* **	83.2	76.8	- 7.7	35.5	36.7	+ 3.4
1987* (Baseline)	124.8	103.4	-17.1	50.9	47.8	- 6.1

	IFR Aircraft Handled (In millions)			Flight Services (In millions)		
	1975	1976	Percent Change	1975	1976	Percent Change
Actual						
1975		23.9			58.2	
Forecast						
1977*	25.6	25.7	+ 0.4	72.9	65.6	- 10.0
1978*	26.7	26.7	0.0	80.2	69.5	- 13.3
1979*	28.0	27.7	- 1.1	85.8	72.3	- 15.7
1980* **	29.0	28.9	- 0.3	89.9	74.7	- 16.9
1987* (Baseline)	39.4	37.7	+ 4.3	143.6	114.7	- 20.1

* Forecasts. Forecasts for fiscal years 1977 and beyond are presented for the new fiscal period (October 1 through September 30), the data for FY 1976 is the old fiscal period (July 1 through June 30).

** Forecasts shown here are the baseline forecast.

The increase in the instrument operations forecast over last year's forecast is due to expected increases for general aviation and air taxi. Additionally, 14 new airports have commissioned Stage III of expanded area radar service. Current air carrier instrument operations forecasts are lower than last year's forecasts (5 to 7 percent lower for each of the forecast years).

The present forecasts of total IFR aircraft handled are quite close to those indicated in September 1975. Increases in general aviation and air taxi IFR aircraft handled are offset, for the most part, by decreases in the forecasts of air carrier IFR aircraft handled.

Current forecasts for all elements comprising total flight services are lower as compared to last year's forecasts. Numerically, the largest differences occur in the forecasts of pilot briefs. This, as well as the weights employed in the computational procedures, cause pilot briefs to be the major contributor to the decline in the forecast of total flight services.

It should be noted that the fiscal year forecasts for 1977 and beyond are based on the new fiscal year period, October 1 through September 30.

Further detail on specific projections and their underlying assumptions is presented in the following text and in the Appendices. Additional information is available from the Aviation Forecast Branch (AVP-120), Federal Aviation Administration, Washington, D.C. 20591, phone 202-426-3103.

HIGHLIGHTS OF FISCAL YEAR 1976

The recovery of the general economy had a substantial impact on the growth of aviation activity during FY 1976. In addition to this the price of fuel increased at a rate below that of FY 1974 and FY 1975. Because of this the impact of fuel price increases was not as great as had been expected.

Air Carriers

During FY 1976 the air carriers benefited from the effects of the general improvement in the economy through an increase in enplanements. However, this increase in air travelers was absorbed mostly in an increase in industry average load factor rather than an increase in air carrier operations. Industry passenger load factor increased from 52.2 percent in FY 1975 to 55.6 percent in FY 1976 while air carrier operations remained almost constant.

Although domestic air carrier operations remained nearly constant during FY 1976, available seat-miles increased by 2 percent. Part of this increase was brought about by the continued introduction of wide-body jets and larger standard-body jets; the remainder was caused by an increase in the seating density on many of the aircraft that the air carriers had on hand.

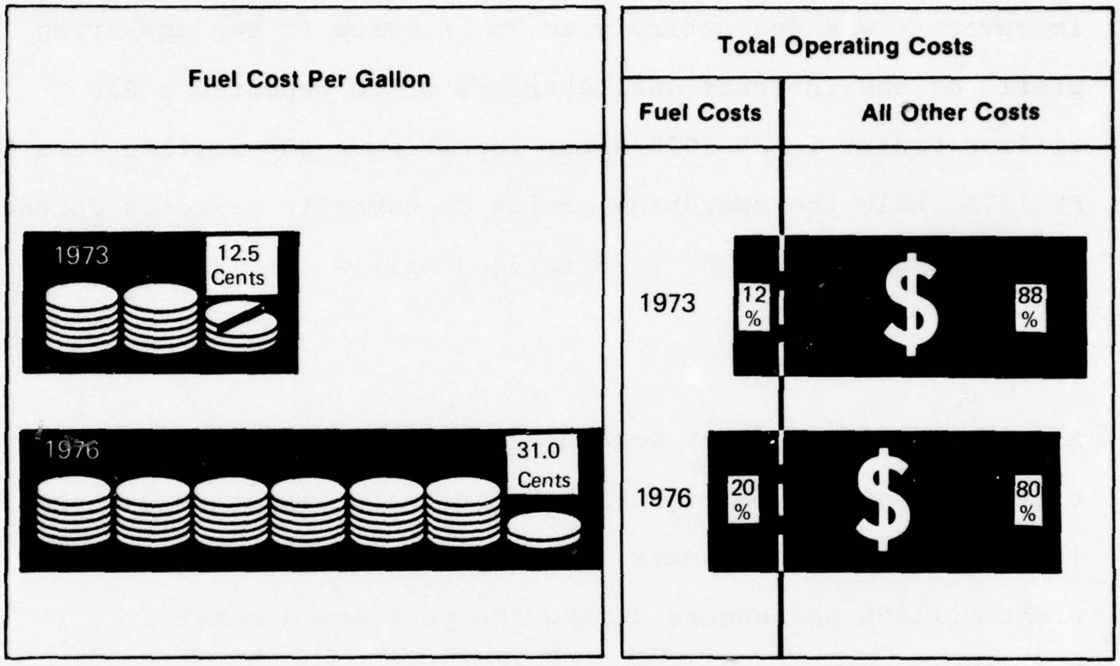
The United States international carriers during FY 1976 again decreased their worldwide operations. The decrease in departures in FY 1976 was 8.8 percent from FY 1975. However, because of the increased use of wide-body aircraft, available seat-miles decreased by only 3 percent during FY 1976.

Revenue passenger miles increased by 8.4 percent during FY 1976 due mainly to the recovery of the domestic general economy. Domestic revenue passenger miles increased by 9.5 percent while international revenue passenger miles increased by 3.9 percent. This resulted in a domestic load factor of 56.3 percent compared to 52.7 percent for FY 1975. The FY 1976 international load factor was 52.7 percent compared to 50.2 percent for FY 1975.

Air cargo, which includes freight, express and mail, increased by 5 percent during FY 1976. Domestic air cargo revenue ton-miles increased by 4 percent while international cargo revenue ton-miles increased by 6 percent.

Fuel prices continued to rise for domestic and international air carriers during FY 1976. In June of 1973 the average price of fuel was 12.5 cents per gallon for the total industry. By June 1976, the average industry price had increased to 31.0 cents per gallon. As a percent of total airline operating costs, fuel had risen from 12 percent in 1973 to approximately 20 percent in 1976. See Figure 1.

FIGURE 1
AIR CARRIER FUEL EXPENSES: COST PER GALLON AND PERCENTAGE OF TOTAL COSTS



During FY 1976 the domestic and international air carrier industry experienced a 2 percent increase in operating revenue per revenue ton-mile. This added to a 7 percent increase in total revenue ton-miles resulted in an increase of 9.2 percent in total operating revenue. During this same period total operating expenses increased 9.1 percent resulting in an increase in net income when compared with FY 1975.

For FY 1976 the operating profit for the total air carrier industry was $333 million, a 19 percent increase above the $281 million profit reported for FY 1975. However, the improvement was due entirely to an increase in the operating profit of the international carriers which reported a $30 million profit in FY 1976 after reporting a $36 million loss in FY 1975 while the operating profit of domestic carriers decreased from $316 million in FY 1975 to $303 million in FY 1976.

Air Taxis

Air taxi activity, both scheduled (commuter) and unscheduled, continued to grow through FY 1976 but at a lesser rate than in the previous four years. Air taxis carried an estimated eight million passengers during the year and generated 2.9 million operations. The trend toward replacement of certificated carriers by commuters at low density traffic points has continued. The Civil Aeronautics Board authorized such substitution at an additional seven points during FY 1976 making a total of 55 points now receiving replacement service.

General Aviation

In CY 1975, despite the impact of the national recession which affected most industries adversely, the general aviation industry experienced the best dollar sales year in its history.

The General Aviation Manufacturers Association (GAMA), representing companies which produce 99 percent of the Nation's general aviation aircraft and equipment, shipped approximately 14,075 aircraft valued at over one billion dollars. Production continued at a relatively high level during the first six months of CY 1976. Net billings totaled nearly $600 million for the 6 month period, up 19 percent from the comparable period in 1975.

Exports of general aviation aircraft remain a significant source of earnings to the industry. In CY 1975, exports accounted for 30 percent of the total dollar value of U.S. shipments. During the first six months of CY 1976, 28 percent of total shipment value was exported.

The size of the active GA fleet increased from 161,500 as of January 1, 1975, to 168,500 one year later, up 4.3 percent. Similarly, hours flown by GA aircraft increased from 33.3 million in FY 1975 to 35.0 million in FY 1976, up 5.1 percent. The percentage increases in fleet size and hours flown are both somewhat lower than the increases for the preceding year.

The total number of active pilots was 725,059 as of January 1, 1976, down slightly from the 730,541 reported one year earlier. A substantial increase in the number of

airline transport pilots was offset by declines in the number of student and commercial pilots. The number of instrument rated pilots increased by more than 2 percent above the January 1, 1975, level.

Military

Military aircraft operations at FAA operated control towers totaled 2.7 million operations during FY 1976, which was the same as FY 1975. Instrument operations dropped slightly in FY 1976 to 3.7 million. Military aircraft handled at FAA air route traffic control centers showed a slight decrease from 4,370,000 in FY 1975 to 4,166,000 in FY 1976.

FAA Operations

Total aircraft operations increased by 5.9 percent from 59.0 million in FY 1975 to 62.5 million in FY 1976. Part of this increase may be attributed to a net gain of 12 towers during FY 1976. Over this time period, itinerant operations increased by 5.6 percent and local operations by 6.5 percent. These percentage increases are higher than those for the 1974 to 1975 fiscal years when aviation activity was affected adversely by the recession. Thus, the increase in the rate of growth of operations may be attributed to the impact of the recovery of the

general economy on aviation. The increase in itinerant operations resulted mainly from growth in general aviation and air taxi operations since air carrier operations remained near their FY 1975 levels. Similarly, the growth in local operations was due to increases in general aviation operations.

The increase in total instrument operations between FY 1975 and FY 1976 was 7.2 percent, somewhat less than the FY 1974 and FY 1975 increase of 8.7 percent. Part of this growth reflects the increased use of avionics by the general aviation fleet. Both GA and air taxi instrument operations increased over the FY 1975 to FY 1976 time frame. Air carrier instrument operations remained unchanged; but military operations declined slightly from the FY 1975 level.

In FY 1976, total IFR aircraft handled by air route traffic control centers increased by 1.0 percent from the 23.6 million recorded in FY 1975. Air carrier IFR flying showed no increase from its FY 1975 level, while air taxi and GA IFR aircraft handled increased by 7.7 percent and 9.1 percent, respectively. Military IFR aircraft handled declined by 4.6 percent.

The total number of flight services provided by flight service stations and combined station/towers decreased slightly from 58.3 million in FY 1975 to 58.2 million in FY 1976.

This series has exhibited an uninterrupted upward trend since its inception in 1962; however, its growth rate has dropped considerably during the last few years. The FY 1976 counts of pilot briefs and aircraft contacted were unchanged from their FY 1975 levels. Flight plans originated increased slightly.

AVIATION FORECAST HIGHLIGHTS

Air Carrier Passenger Traffic

During FY 1976, the scheduled air carriers handled traffic volumes within 1 percent of the 1975 Aviation Forecasts. The economic recovery which contributed to this traffic growth is expected to continue. As a result, the total industry revenue passenger enplanement (ENP) traffic is expected to increase at a 5.9 percent annual rate through FY 1988, while the revenue passenger mile (RPM) average annual growth rate will reach 6.5 percent. Much of this growth comes from the international markets. A strengthening world economy is expected to contribute to an annual growth rate in RPM's of 7.3 percent and an ENP growth rate of 6.4 percent per year for the U.S. flag international carriers.

Air cargo which includes freight, express and mail is forecast to continue its strong growth although not at the levels seen in the past. Domestic cargo ton-miles per year are forecast to nearly double between FY 1976 and FY 1988. The average growth rate for domestic air cargo during this period is expected to be 6 percent per year. The domestic air cargo average growth rate is composed of freight and express with an average yearly growth rate of 7 percent and mail with a growth rate

of 2.5 percent. International air cargo revenue ton-miles per year are forecast to increase more than two and one half times between FY 1976 and FY 1988 for an average yearly growth rate of 8.5 percent.

Air Taxi

It is anticipated that substantial growth will occur in air taxi operations over the forecast period. Forecasts for scheduled air taxis (commuters) are particularly optimistic for a number of reasons. In the present climate of pressure for regulatory reform, the Civil Aeronautics Board has shown an increasing tendency to allow local service carriers to abandon unprofitable points in favor of commuters. Since commuters providing replacement service with small aircraft usually offer more frequent flights than certificated carriers, they create a substantial increase in operations. This trend is expected to continue and even accelerate over the next decade.

General Aviation

Just as passenger traffic can be used as an important measure of air carrier activity, the general aviation fleet size and hours flown are important indicators of general aviation activity. For example, the annual growth rate in the active GA fleet of 4.0 percent during the 1977-1988 period emphasizes an increasing popularity of general aviation flying. Moreover, the 6.3 percent

annual increase in GA hours flown during the same period reflects a greater utilization of the active aircraft. Interestingly, the largest growth occurs in the multiengine and turbine classes of aircraft. This points to an increased sophistication among the GA pilots.

Military

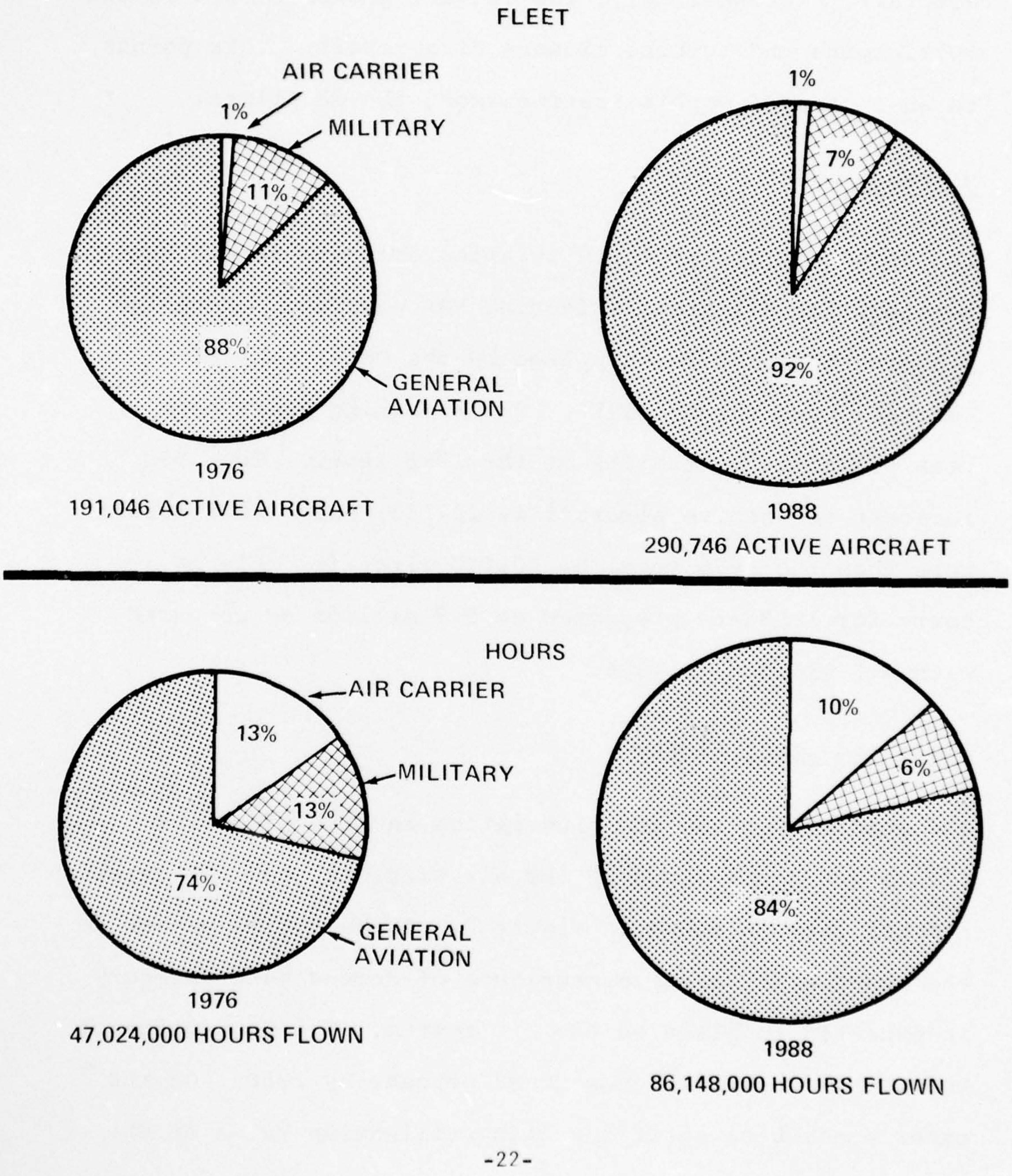
The forecasts for military aviation activity remain nearly constant for all areas affecting FAA workload. Detailed planning information, supplied by the Department of Defense, goes through 1983. The remaining years have been projected by the FAA at the 1983 level. The 1983 forecast for active aircraft is 20,153, only 130 aircraft more than the 1976 total of 20,023 aircraft. Flying hours for 1983 are projected at 5.7 million as compared with 6.5 million in 1976.

Fleet and Hours Flown

A comparison of the changing ratios in size of active fleets and hours flown by the air carriers, general aviation and military is shown in Figure 2. These ratios emphasize the changes in relative magnitude of demand each category is expected to place on the air system. The GA portion of the total fleet will grow to 92 percent by 1988. On the other hand, because of the high utilization rates of the air carrier aircraft, the air carrier hours will remain a significant factor in the total hours.

FIGURE 2

COMPARISON OF ACTIVE AIRCRAFT FLEET TO HOURS FLOWN

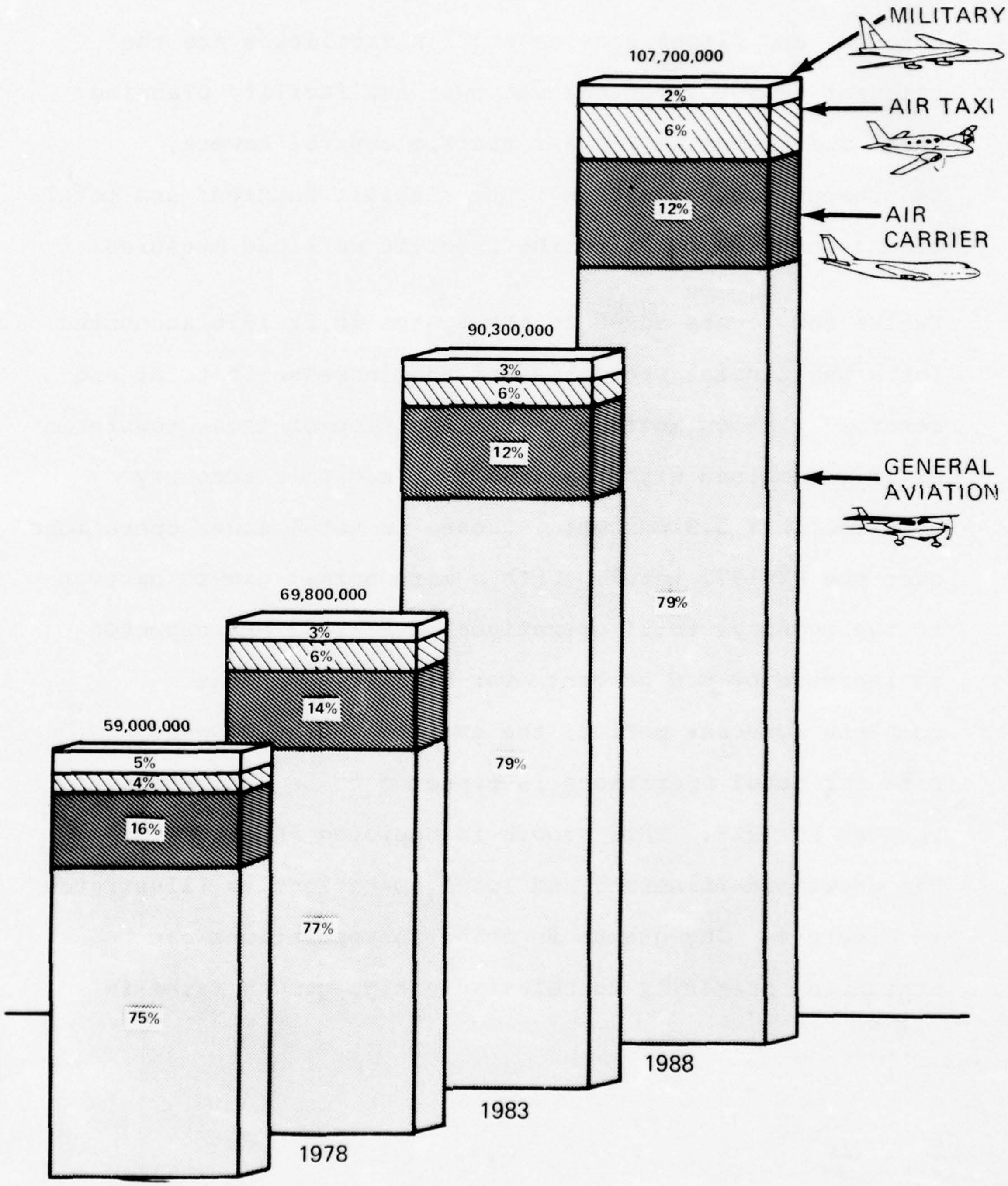


FAA Workload

Although fleet size and hours flown are important measures of total aviation activity, activity at FAA terminal, enroute, and flight service station facilities are the relevant measures for FAA manpower and facility planning. Total operations at FAA air traffic control towers, instrument operations, en route aircraft handled, and total flight services comprise the specific workload measures.

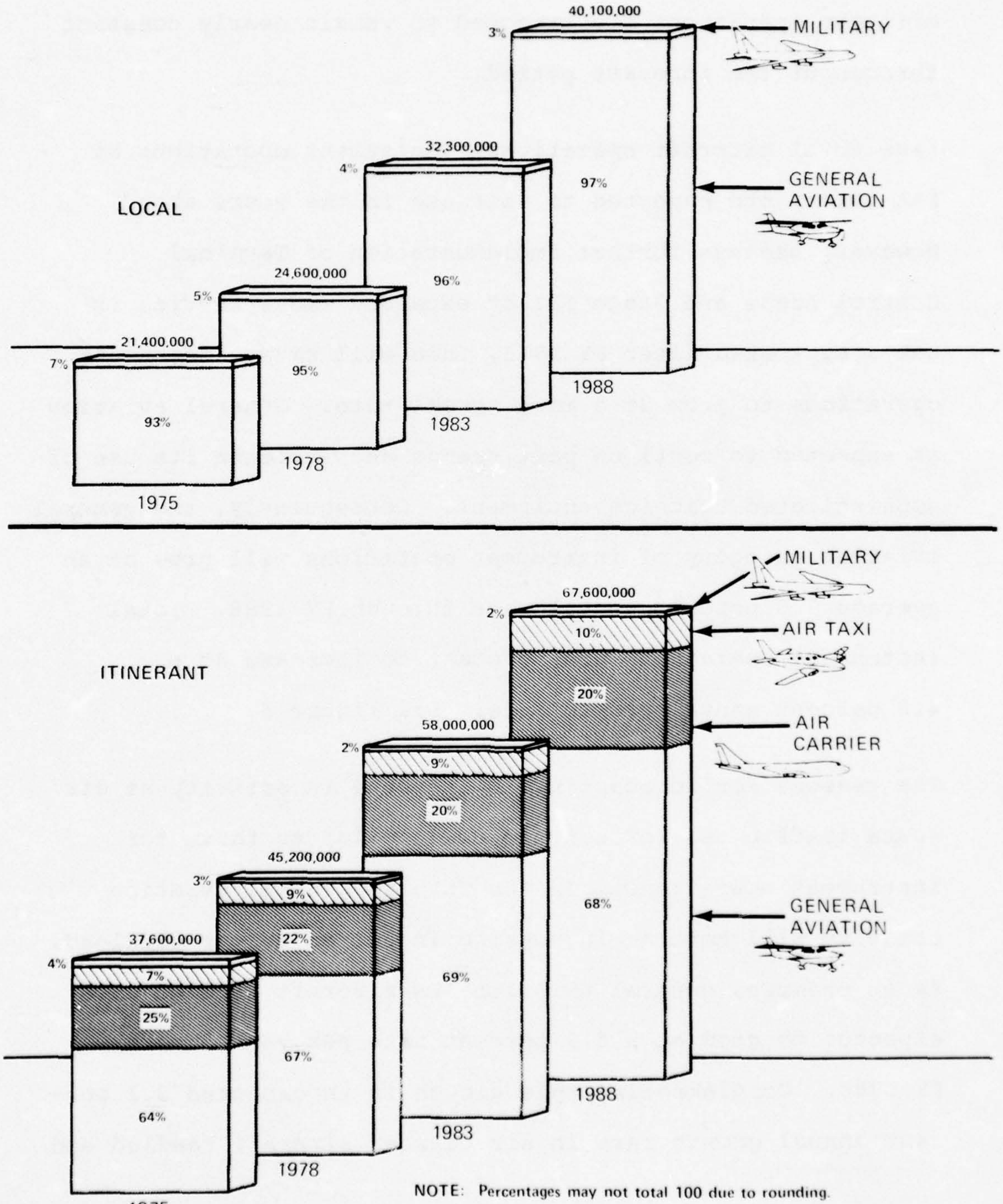
Twelve new towers added to the system in FY 1976 accounted for a substantial proportion of the increase in total and general aviation activity. The addition of these towers in FY 1976 combined with the impact of economic recovery resulted in a 5.9 percent increase in total tower operations over the FY 1975 total. With a more normal growth pattern in the economy, total operations in FY 1977 are expected to increase by 6.6 percent over FY 1976. For the complete forecast period, the average yearly growth rate for total operations is expected to be 4.6 percent through FY 1988. This growth is depicted in Figure 3. The growth in itinerant and local operations is illustrated in Figure 4. The growth in itinerant operations can be attributed primarily to relatively high growth rates in

FIGURE 3
TOTAL AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE



NOTE: Percentages may not total 100 due to rounding.

FIGURE 4
LOCAL AND ITINERANT AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE



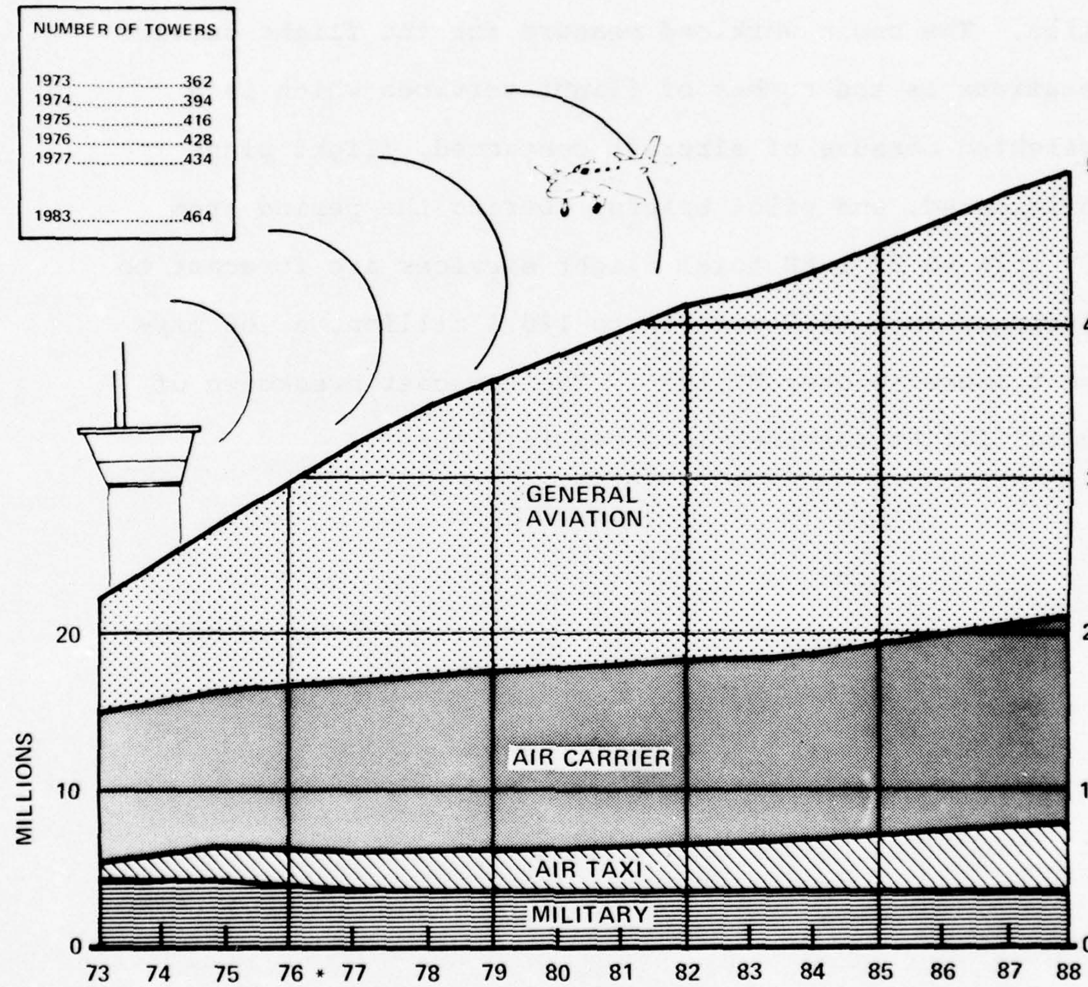
NOTE: Percentages may not total 100 due to rounding.

air taxi and general aviation activity plus some increase in air carrier operations. The increase in local operations is attributable solely to general aviation since military operations are expected to remain nearly constant throughout the forecast period.

Like total aircraft operations, instrument operations at FAA towers are expected to increase in the years ahead. However, because further implementation of Terminal Control Areas and Stage III of expanded radar service is not anticipated after FY 1976, this will cause instrument operations to grow at a more normal rate. General aviation is expected to continue past trends and increase its use of sophisticated avionics equipment. Consequently, the general aviation category of instrument operations will grow at an average 7.0 percent annual rate through FY 1988. Total instrument operations are forecast to increase at a 4.8 percent annual growth rate. See Figure 5.

The reasons for forecasting an increase in activity at air route traffic control centers are similar to those for instrument operations. In the future, general aviation activity will have an increasing impact on center workload. As an example, general aviation IFR aircraft handled are expected to grow at a 6.9 percent rate per year through FY 1988. Complementing this growth is an expected 3.1 percent annual growth rate in air carrier aircraft handled and

FIGURE 5
INSTRUMENT OPERATIONS AT
AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE



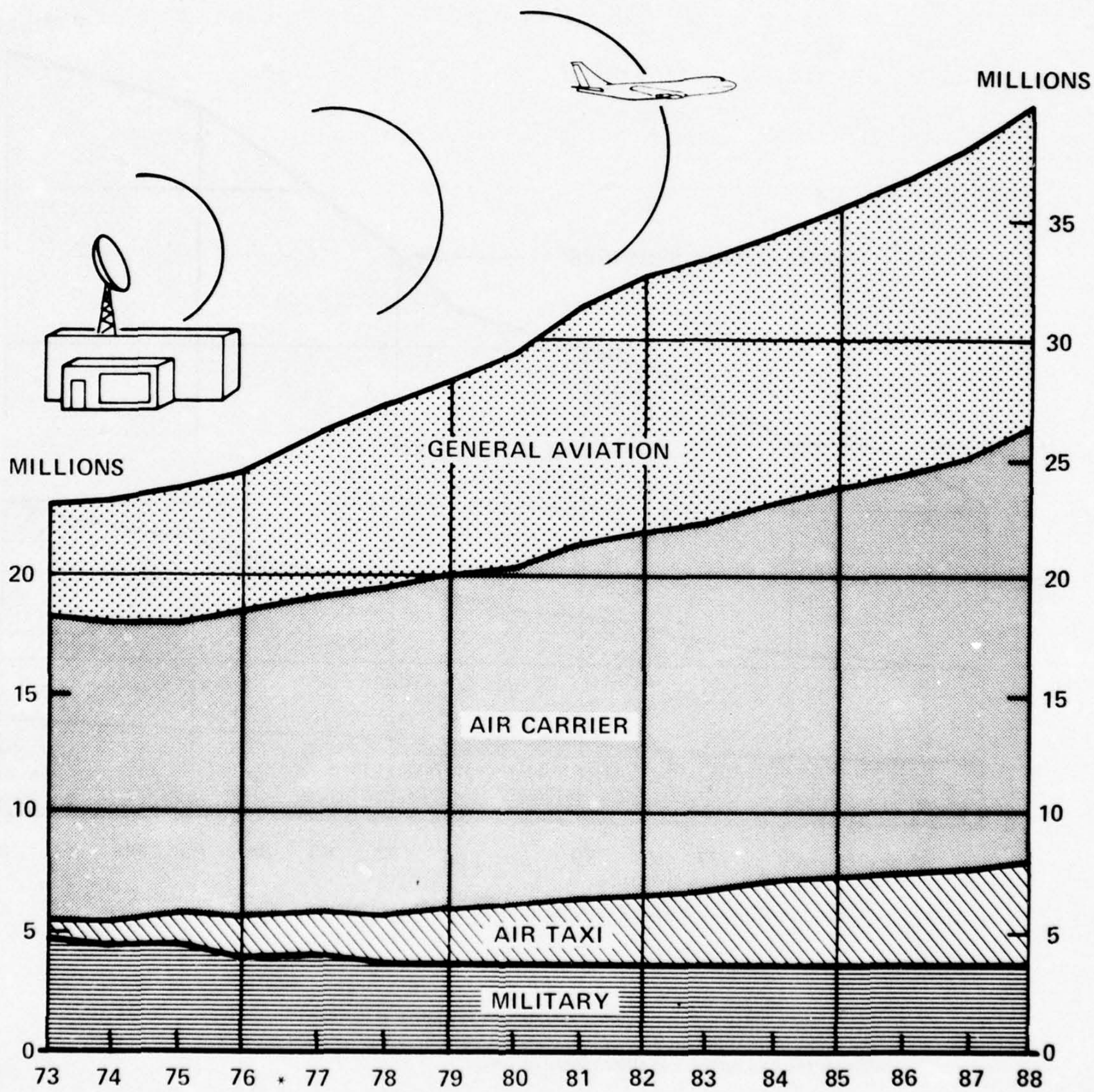
FISCAL YEARS (*indicates transitional quarter)

no growth in military activity. Figure 6 depicts the growth of activity at centers by user category.

Historically, flight service stations have provided the greatest share of their flight services to general aviation. The basic workload measure for the flight service stations is the number of flight services which is a weighted measure of aircraft contacted, flight plans originated, and pilot briefs. During the period from FY 1976 to FY 1988 total flight services are forecast to increase from 58.2 million to 120.1 million, a 106 percent increase over FY 1976. The forecast breakdown of total flight services is shown in Figure 7.

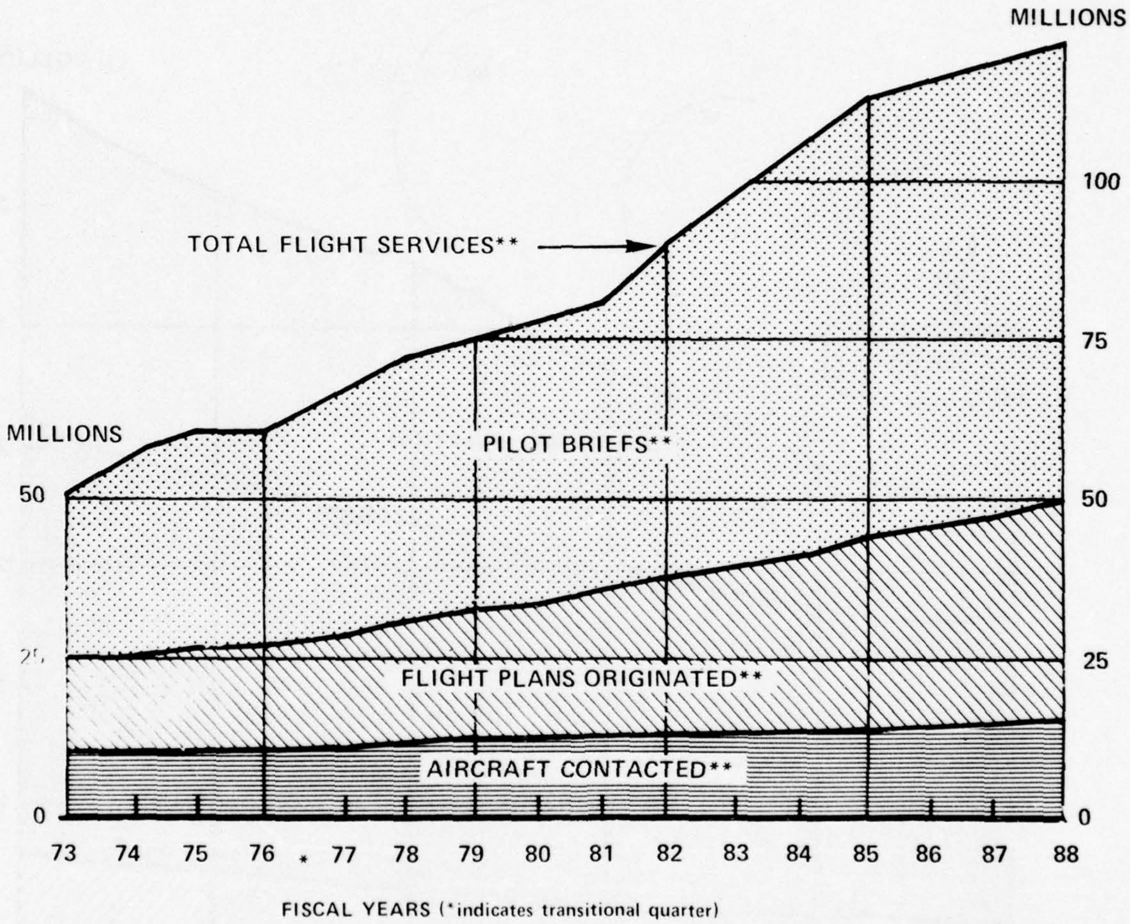
FIGURE 6

IFR AIRCRAFT HANDLED BY FAA AIR ROUTE TRAFFIC CONTROL CENTERS



FISCAL YEARS (*indicates transitional quarter)

FIGURE 7
TOTAL FLIGHT SERVICES AT FAA FLIGHT SERVICE STATIONS AND COMBINED STATION/TOWERS



** Total Flight Services is a weighted workload measurement derived by multiplying pilot briefs and flight plans originated by two and adding the number of aircraft contacted. This graph *depicts the components in their weighted form.*

METHODS AND ASSUMPTIONS

Air Carrier Passenger Demand Forecasts

Air carrier operations form one major segment of the workload borne by FAA facilities. Since future changes in demand for air transportation affect air carrier planning, forecasts of revenue passenger miles (RPM) and enplanements (ENP) as measures of that demand are needed to forecast air carrier activity. Increases in these measures of passenger traffic during FY 1976 are correlated directly to the economic recovery. If the economy continues to follow the expected growth path, air carrier demand is expected to reach levels similar to those forecasted in September 1975.

Methodology. The forecasts are based on the assumption that demand for air carrier services depends upon the economy. The exact relationships between various measures of economic activity and air carrier demand were econometrically estimated based on historical data. The variables determining RPM and ENP were then forecasted, and demand forecasts were generated based on the estimated historical relationships. The economic variables used include:

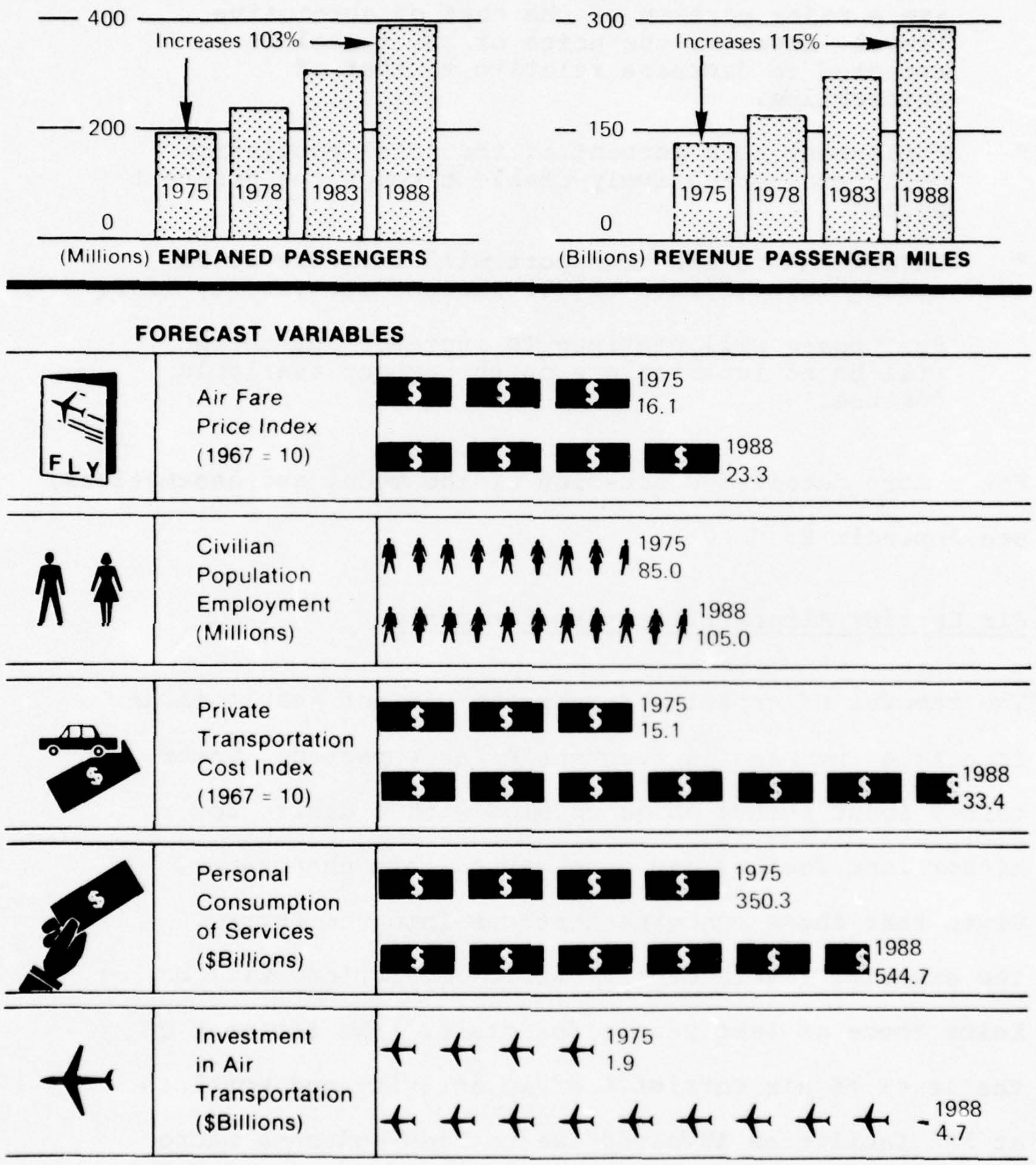
- Personal consumption of services
- Number of civilians employed
- Air transport investment
- Cost of automotive transportation
- Air fares

Personal consumption of services is used to represent the impact of income. The number of civilians employed reflects the impact of population growth on demand. Investment in plant and equipment by the air transport industry is a surrogate for level of service. The relationship between air fares and the costs of private transportation represents price competition from other modes. Generally, the model shows that as air fares increase demand falls, and that as income, population, and investment increase demand rises. See Figure 8.

Assumptions. The forecasts generated by the model assume that the historical relationships among these variables will continue into the future. The assumptions about the economy are summarized below.

- As the economic recovery continues through 1977, it will encourage consumer spending of services. This phenomenon will be accentuated by a shift away from durable goods purchases.

FIGURE 8
SCHEDULED DOMESTIC PASSENGER TRAFFIC AND FORECAST VARIABLES



- Both air fares and the cost of automobile transportation are expected to continue to increase through the forecast period. Because fuel costs are a major portion of the cost of automotive travel, however, the price of air travel is expected to decrease relative to that of automobiles.

- Employment as a percent of the total population will remain relatively stable through the forecast period.

- Investment in air transport will increase at an average growth rate of 7.2 percent per year by 1986.

- Fuel costs will continue to increase but there will be no restrictions on the amount available for use.

For a more detailed discussion of the model and assumptions, see Appendix B.

Air Carrier Aircraft Activity Forecasts

The removal of capacity agreements did not result in an immediate increase in frequencies as expected. Uncertainty about future costs coupled with a desire for higher load factors may have caused this phenomenon. Given that these concerns continue into the future, the expected levels of air carrier operations will be below those of last year's forecasts. The forecast of the level of air carrier traffic activity and workload at FAA facilities involved two methodologies--a macro and a micro method. Using the two methods, forecasts of operations were made, compared, and adjusted for consistency.

Macro-methodology. This model forecasts towered aircraft operations for the whole air carrier industry. Forecasts of passenger traffic and the industry's operating behavior form the basis of this model. The variables used were:

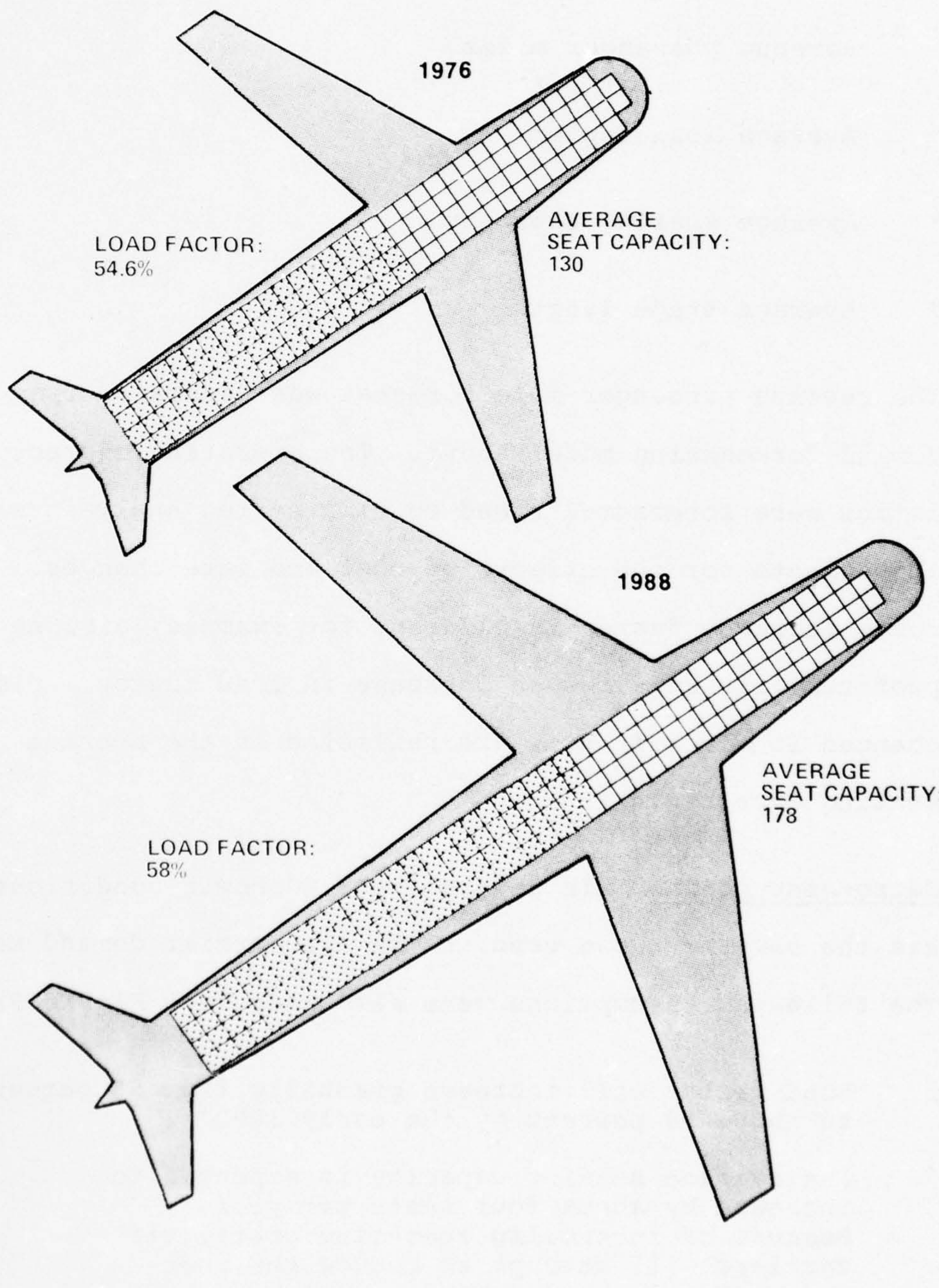
- Revenue passenger miles
- Average load factor
- Average seating capacity
- Average stage length

The revenue passenger mile forecast was generated from the demand forecasting model above. The operating characteristics were forecasted based on time series analysis with adjustments for the effects of cost and fare changes. When costs increase faster than fares, for example, airline profitability requires an increase in load factor. Similarly, changes in aircraft size are reflected in the average seating capacity.

Macro-assumptions. In general, the economic conditions assumed are the same as those used in the air carrier demand model. The following assumptions were also made (see Figure 9):

- Load factor will increase gradually from 55 percent to about 58 percent by the early 1980's.
- The average seating capacity is expected to increase by about four seats per year. Because of increasing operating costs, air carriers will attempt to reduce the cost per seat-mile by purchasing more wide-body aircraft.

FIGURE 9
AVERAGE DOMESTIC AIR CARRIER SEATING CAPACITY AND LOAD FACTOR



- The average stage length will increase by about three miles per year.

<u>Micro-methodology</u>. Individual forecasts for each of the carriers in the industry form the basis of this forecast. The driving variable was the number of aircraft, by type, each carrier has on hand and on order. The estimates for future types and numbers of aircraft were made after discussions with many of the air carriers and all the major U.S. aircraft manufacturers. Additional aircraft orders beyond those announced publicly were estimated in order to provide the increased capacity needed to carry anticipated traffic growth; to provide for retirement of aircraft; and to provide for individual airlines to maintain a competitive position with other airlines. Judgement, influenced by the discussions held with knowledgeable people within the industry, was used to project the individual carrier fleets by aircraft types beyond the years for which aircraft order information was available. Service patterns and frequencies of service were also forecast in general terms after discussions with members of the industry.

Micro-assumptions.

Aircraft

2 engine	°	Continued introduction of DC-9 and 737 (both new and purchased from trunk carriers) into local service carrier fleets
	°	Stretch versions of present 2 engine aircraft will replace remaining turboprops in late 1970's
	°	Introduction of a new wide-body aircraft in early 1980's
3 engine	°	Continued introduction of wide-body aircraft and 727-200
	°	Introduction of new aircraft in early 1980's with seating capacity between 727-200 and wide-body aircraft
	°	Stretch versions of present wide-body aircraft will appear in mid-1980's
4 engine	°	Retirement of nonfan and some older fan-jet aircraft will occur during the forecast period

Seating Capacity

° Continued decrease in size of first class section with resulting increase in size of coach section

° Number of seats abreast will increase by one in wide-body jets in late 1970's

Load Factor

° Will increase from present 55 percent to 58 percent by the early 1980's

Air Freight Forecasts

The growth of air freight demand which includes express but excludes mail is a function of the general economy of the United States and its world trading partners, the growth of time sensitive shipments, and the difference between air and surface mode service quality and prices. The relationships between the supply side prices, the general economy and the air freight traffic have been estimated through multiple regression model. Separate equations have been developed for U.S. domestic services and for international services to and from U.S. airports by U.S. flag and foreign carriers.

Methodology. An econometric forecasting model has been developed consisting of a series of thirteen equations which relate air freight demand to the two quantifiable variables (i.e., GNP and average revenue yield as a surrogate for prices). One equation forecasts revenue ton-miles of U.S. domestic air freight services. Twelve equations forecast revenue tons of imports from and exports to six world regions.

The explanatory variables for the domestic equation are revenue ton-miles and average revenue yields (in constant dollars) for the aggregate of freight and express traffic for all scheduled and nonscheduled domestic services reported by the CAB and real U.S. GNP. The time period of the historical data is 1950 to 1974. It encompasses substantial variation in economic activity, technological innovation in air service, and an increasing awareness of the benefits of air service to larger segments of the goods distribution industry.

The basis for the U.S. international equation is a 10 year time series (1965-1974) of U.S. exports by air and U.S. imports by air reported by the Department of Commerce and average revenue yields (in constant dollars) for the aggregate of freight and express for all scheduled and non-scheduled international services of the U.S. flag carriers. Foreign flag revenue data is not available and it was assumed that average revenue yields would be equal. Unique average revenue yield values between the United States and each of the six world regions would have been more accurate but data is unavailable. United States' GNP is used as a variable for imports to the United States and an aggregate gross product (in U.S. dollars) for each world region is used for the U.S. exports. Complete documentation of the model and the file of economic and traffic data compiled for the

model will be included in an FAA report on air cargo which will be available in the early part of 1977.

Assumptions. The econometric model approach has been taken to provide a base forecast founded on the premise that no dramatic technological or socio/political changes will occur in the forecast time frame. This approach assumes that shipper/receiver mode choice determinants are economic, remain essentially unchanged in the aggregate, and are adequately reflected by the equation variables. It is felt that this model is at the current state-of-the-art of econometric forecasting and, given the available data, the limits of the approach have been reached. Significant improvements in the accuracy or precision of the forecasts require individual forecasts of commodity flows, mode split models, and more precise modeling of the price and service differential between the surface and air options available to the various groups of transportation users.

General Aviation Activity Forecasts

General aviation (GA) activity is expected to increase faster than total aviation activity, placing additional workloads on FAA facilities and manpower. Based on current data, total GA operations reached 47.6 million in FY 1976, exactly as forecast in the September 1975 Aviation Forecasts Publication. GA instrument and

local operations were somewhat higher than forecast (11 percent and 1 percent, respectively). The growth rate of total flight services has decreased considerably. Total flight services increased slightly in FY 1976 and the computed number of total flight services fell far short of the predicted level (12 percent).

General aviation IFR aircraft handled increased essentially as forecast. The increases in general aviation activity at FAA facilities are due partly to the addition of 12 new towers during FY 1976 and to the general economic recovery. The growth in instrument operations and in IFR aircraft handled reflects the increasing sophistication of general aviation aircraft and the increasing use of avionics equipment by general aviation pilots. Interestingly, VFR flight plans are below last year's estimates. The slow rate of growth in VFR flight plans may be attributed to the increased use of sophisticated electronic navigation equipment in GA aircraft mentioned above.

Methodology. Most of the forecasts of general aviation activity were derived from a simultaneous equation econometric model relating measures of activity to economic and demographic variables. The number of civilians employed, expenditures on plant and equipment by the

aircraft industry, factory sales of automobiles, real per capita disposable income and aircraft operating costs were the important exogenous variables.

Activity measures not estimated by this model were generated from a time series analysis. Forecasts of variables such as average hours flown per operation and average fuel consumption per hour were based on historical trends. These ratios were then applied to the operations forecasts.

<u>Assumptions</u>. The general aviation activity forecasts are based on economic assumptions consistent with air carrier RPM and activity forecasts. No further expansion in terminal control areas or Stage III of expanded radar service is assumed beyond 1976 levels.

The current economic outlook may be characterized by short-term optimism modified by more cautious overtones for the more distant future. The overall outlook is for moderate economic growth, declining unemployment, and decelerating inflation rates. In particular, the following detail is extracted from this year's economic forecasts:

- GNP--The declines in real gross national product experienced during 1974 and 1975 have been turned around, and a growth of about 6.6 percent is expected for real GNP during 1976 with an additional 5.1 percent growth for 1977. Significantly lower growth rates are forecasted for real GNP in

the more distant future--the average annual growth for real GNP for the forecast period is about 3.3 percent.

- Prices--Inflation rates of over 11.0 percent and almost 9.0 percent experienced during 1974 and 1975, respectively, are expected to slow to around 5.5 percent in 1976 and 6.1 percent during 1977. Significantly higher rates (about 7.5 percent) are forecasted from 1978 through 1980, followed by rates of inflation around 5.3 percent through 1988. The average annual inflation rate for the forecast period is 6.3 percent.

- Income--Real personal disposable income, which declined by 3.4 percent and 2.2 percent during 1974 and 1975, respectively, is expected to grow by 6.5 percent during 1976 and by less than 1.0 percent during 1977. Except for 1982, annual increases in the range of 1.0 percent to 4.0 percent are expected for all subsequent years. An average annual increase of about 2.3 percent is expected in real personal disposable income over the forecasted period.

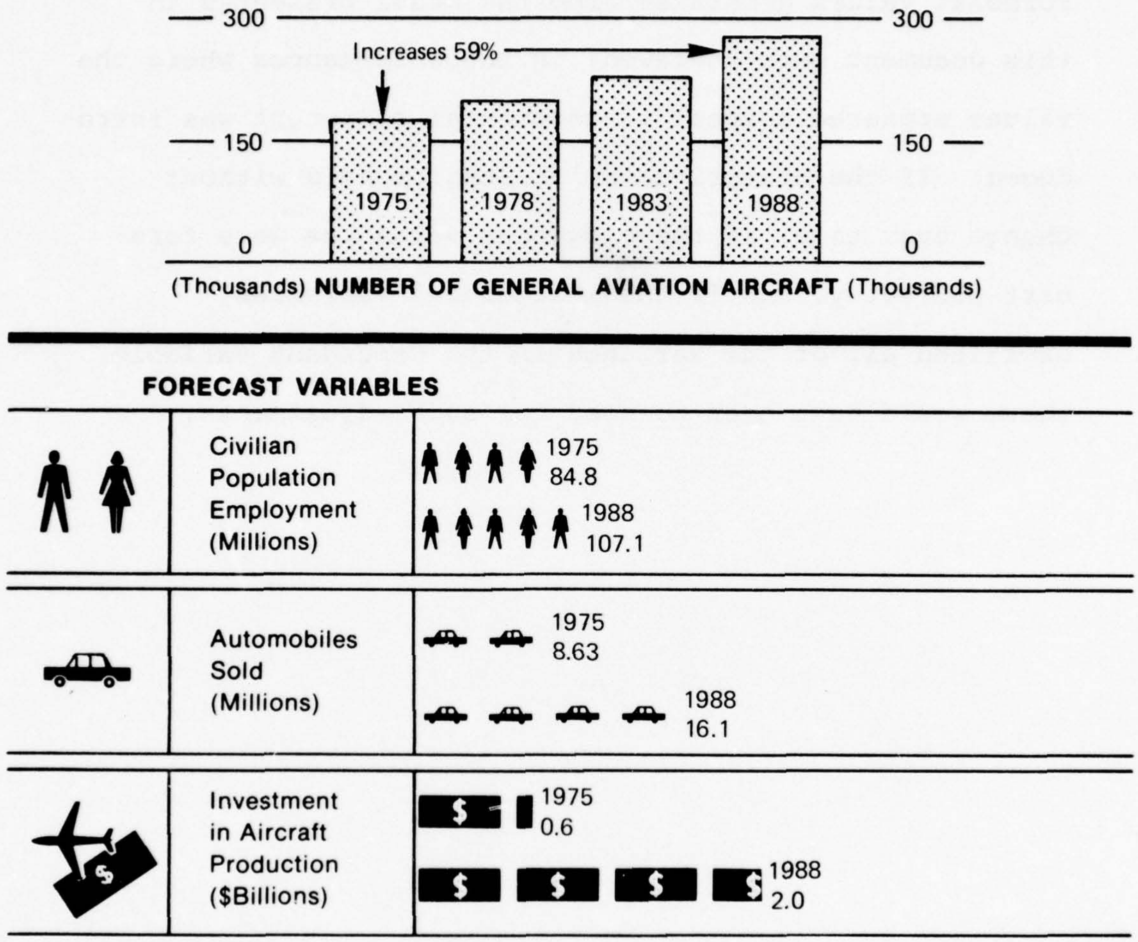
- Employment--During 1974 the economy experienced a decline in the rate of increase in employment, and in 1975 employment declined by 2.9 percent. During 1976 and 1977, civilian employment is expected to increase by slightly over 2.0 percent each year. The average annual growth rate for employment over the forecasted period is 1.8 percent.

Specific economic variables used in the fleet size forecast equation are given in Figure 10. A complete discussion of the model is presented in Appendix C.

Military Activity Forecasts

All military operational activity forecasts are based on information provided by the Department of Defense. Military operations are forecast to hold nearly constant throughout the forecast period.

FIGURE 10
GENERAL AVIATION AIRCRAFT FLEET AND FORECAST VARIABLES



Adjustments

Forecast values generated from the model presented in this document were reviewed; in those instances where the values appeared suspect a judgemental component was introduced. If the historical relationships held without change over time, if the exogenous variables were forecast perfectly, and if the independent variables explained all of the variance in the dependent variable, there would have been no need for such adjustments.

AVIATION INDUSTRY FORECASTS

Fiscal Years 1977-1988

Tables 1 through 5 present forecasts of passenger and cargo traffic fleet size, and the hours and miles that will be flown by the air carrier fleet. Tables 6 through 8 are forecasts of the general aviation fleet size and its use. Table 9 is a forecast of the military fleet size. Table 10 is a forecast of fuel consumption for the air carriers and general aviation. Tables 11 through 19 display forecasts of the different measures of air traffic activity and workload at FAA terminal, en route, and flight service station facilities. The data in Table 20 is a forecast of the number of active pilots by type of certificate.

Table 1

UNITED STATES CERTIFICATED ROUTE AIR CARRIER
SCHEDULED PASSENGER TRAFFIC

Fiscal	Revenue Passenger Enplanements (millions)			Revenue Passenger-Miles (billions)		
Year	Total	Domestic	International	Total	Domestic	International
1972	182.9	164.5	18.4	144.2	112.3	32.0
1973	197.3	178.4	19.0	157.9	122.6	35.4
1974	208.1	189.5	18.6	165.0	130.0	35.0
1975	201.9	184.9	17.0	159.0	127.7	31.3
1976	211.8	195.1	16.7	169.5	137.3	32.2
1977T*	58.4	53.8	4.6	46.2	37.7	8.5
1977*	232.5	214.4	18.1	184.8	150.7	34.1
1978*	243.6	224.0	19.6	195.0	157.7	37.3
1979*	258.9	237.8	21.1	208.5	167.9	40.6
1980*	278.3	255.3	23.0	225.9	181.8	44.1
1981*	298.0	273.4	24.6	243.7	195.5	48.2
1982*	313.6	287.2	26.4	258.4	206.2	52.2
1983*	330.9	303.0	27.9	274.2	218.5	55.7
1984*	350.9	321.8	29.1	291.7	233.0	58.7
1985*	369.8	339.1	30.7	308.9	246.5	62.4
1986*	388.0	355.9	32.1	325.6	259.8	65.8
1987*	406.6	373.0	33.6	343.2	273.8	69.4
1988*	428.5	393.2	35.3	361.8	288.6	73.2

* Forecast

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 2

UNITED STATES AIR CARGO TRAFFIC(1)
ALL SERVICE AT UNITED STATES AIRPORTS(2)

Fiscal Year	Revenue Cargo Enplaned Tons(3) (thousands)			Revenue Cargo Ton-Miles(4) (millions)		
	Total	Domestic	International	Total	Domestic	International
1972		3301			3395	
1973		3623			2662	
1974	4356	3427	929	9479	3632	5847
1975	4311	3369	942	9322	3664	5658
1976	4782	3752	1030	10511	4111	6400
1977T	1265	985	280	2852	1093	1759
1977	5058	3939	1119	11405	4371	7034
1978	5233	4020	1213	12119	4513	7606
1979	5530	4215	1315	13125	4791	8334
1980	5890	4467	1423	14301	5144	9157
1981	6377	4841	1536	15804	5658	10146
1982	6494	4835	1659	16476	5715	10761
1983	6670	4876	1794	17286	5826	11460
1984	7099	5163	1936	18712	6250	12462
1985	7577	5487	2090	20259	6726	13533
1986	8019	5764	2255	21747	7149	14598
1987	8489	6057	2432	23328	7598	15730
1938	8992	6369	2623	25018	8083	16935

(1) Includes Freight Express and Mail
(2) Includes scheduled and Non-scheduled service of all U.S. and Foreign Flag Carriers.
(3) Exports only
(4) Includes Imports plus Exports

Table 3

TOTAL AIRCRAFT IN THE SERVICE OF UNITED STATES AIR CARRIERS

(As of January 1)

Aircraft Type	Reported	Forecast											
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total Aircraft	2523	2563	2629	2708	2781	2862	2939	3027	3109	3213	3310	3400	3507
Fixed-wing Aircraft	2516	2556	2620	2698	2770	2850	2926	3013	3094	3197	3293	3382	3488
Jet	2126	2185	2278	2383	2475	2573	2665	2773	2866	2981	3088	3188	3303
2-engine	514	539	577	639	694	766	845	905	949	998	1049	1107	1180
3-engine	1003	1038	1102	1156	1205	1233	1249	1313	1376	1456	1527	1593	1659
4-engine	619	608	599	588	576	574	571	555	541	527	512	488	464
Turboprop	261	260	247	233	220	214	208	198	189	181	172	163	155
1-and 2-engine	189	188	180	175	170	166	162	158	154	150	144	137	130
4-engine	72	72	67	58	50	48	46	40	35	31	28	26	25
Piston	119	111	95	82	74	63	53	42	39	35	33	31	30
1-and 2-engine	76	73	66	60	55	51	47	42	39	35	33	31	30
4-engine	43	38	29	22	19	12	6	-	-	-	-	-	-
Helicopter	7	7	9	10	11	12	13	14	15	16	17	18	19

Note.--Included here are all passenger and cargo aircraft owned or leased by, and in the domestic or international service of the United States certificated route, supplemental, intrastate, and commercial air carriers. Aircraft used for training and aircraft that have been withdrawn from service and are awaiting disposal are not included here. Aircraft in the service of air taxi operators are shown in the general aviation aircraft fleet on another page of this report.

Table 4

TOTAL AIRBORNE HOURS, UNITED STATES AIR CARRIERS

By Fiscal Year (Millions)

Aircraft Type	Reported 1976	Forecast 1977T	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total Aircraft	6.09	1.56	6.20	6.36	6.49	6.80	6.94	7.11	7.32	7.53	7.77	7.86	8.11	8.33
Fixed-wing Aircraft	6.08	1.56	6.19	6.35	6.48	6.79	6.93	7.10	7.30	7.51	7.75	7.84	8.09	8.31
Jet	5.54	1.42	5.65	5.85	6.01	6.30	6.49	6.69	6.91	7.15	7.41	7.53	7.82	8.06
2-engine	1.26	.34	1.35	1.43	1.52	1.67	1.80	2.01	2.11	2.22	2.27	2.35	2.49	2.63
3-engine	2.60	.67	2.68	2.86	2.99	3.15	3.22	3.22	3.35	3.54	3.76	3.83	4.02	4.15
4-engine	1.68	.41	1.62	1.56	1.50	1.48	1.47	1.46	1.45	1.39	1.38	1.35	1.31	1.28
Turboprop	.45	.11	.45	.42	.39	.42	.37	.35	.34	.31	.29	.27	.24	.22
1-and 2-engine	.33	.08	.33	.32	.31	.32	.30	.29	.28	.26	.25	.23	.21	.19
4-engine	.12	.03	.12	.10	.08	.07	.07	.06	.06	.05	.04	.04	.03	.03
Piston	.09	.03	.09	.08	.08	.07	.06	.06	.05	.05	.05	.04	.03	.03
1-and 2-engine	.07	.02	.07	.06	.06	.06	.05	.05	.05	.05	.05	.04	.03	.03
4-engine	.02	.01	.02	.02	.02	.01	.01	.01	-	-	-	-	-	-
Helicopter	.01	.00	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.02	.02

Note--Included here are hours flown by all passenger and cargo aircraft that are owned or leased by and are in the domestic or international service of the United States certificated route, supplemental, intrastate, and contract air carriers. 1977T includes July 1, 1976, through September 30, 1976.

Table 5

TOTAL STATUTE MILES UNITED STATES AIR CARRIERS

By Fiscal Year (Millions)

Aircraft Type	Reported	Forecast												
	1976	1977T	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total Aircraft	2513	656	2548	2610	2658	2940	2814	2853	2943	3024	3099	3146	3264	3353
Fixed-wing Aircraft	2512	656	2547	2609	2657	2739	2813	2852	2941	3022	3097	3144	3262	3351
Jet	2375	602	2415	2487	2545	2636	2714	2759	2853	2952	3047	3098	3220	3311
2-engine	463	120	490	516	543	584	638	684	718	749	767	789	842	894
3-engine	1139	296	1182	1251	1305	1363	1389	1390	1452	1524	1606	1653	1739	1807
4-engine	773	186	743	720	697	689	687	685	683	679	674	656	639	610
Turboprop	110	48	109	105	98	90	88	85	81	65	45	41	38	36
1-and 2-engine	83	41	82	80	76	73	71	69	66	52	36	33	31	29
4-engine	27	7	27	25	22	17	17	16	15	13	9	8	7	7
Piston	27	6	23	17	14	13	11	8	7	5	5	5	4	4
1-and 2-engine	18	4	15	11	10	9	8	7	7	5	5	5	4	4
4-engine	9	2	8	6	4	4	3	1	-	-	-	-	-	-
Helicopter	1	0	1	1	1	1	1	1	2	2	2	2	2	2

Note--Included here are miles flown by all passenger and cargo aircraft owned or leased by and in the domestic or international service of the United States certificated route, supplemental, intrastate, and contract air carriers. Miles for fiscal year 1976 are partially estimated. 1977T includes July 1, 1976, through September 30, 1976.

Table 6

ESTIMATED ACTIVE GENERAL AVIATION AIRCRAFT BY TYPE OF AIRCRAFT

(In thousands)

As of January 1	Total	Fixed Wing				Rotorcraft	Balloons Dirigibles Gliders
		Piston		Turboprop	Turbojet		
		Single-engine	Multi-engine				
1972	131.1	109.1	15.5	1.3	1.2	2.5	1.7
1973	145.0	120.4	17.3	1.4	1.2	2.8	1.9
1974	153.5	126.1	18.7	1.9	1.4	3.1	2.3
1975	161.5	131.9	19.8	2.1	1.6	3.6	2.5
1976	168.5	137.5	20.3	2.5	1.8	3.8	2.5
1977*	181.6	147.7	22.2	2.9	2.0	4.1	2.7
1978*	190.5	154.3	23.6	3.2	2.2	4.3	2.9
1979*	196.9	158.9	24.7	3.4	2.4	4.5	3.0
1980*	203.7	163.8	25.9	3.7	2.6	4.6	3.1
1981*	213.3	170.8	27.5	4.1	2.8	4.8	3.3
1982*	226.0	180.2	29.5	4.6	3.1	5.1	3.5
1983*	233.5	185.3	30.9	5.0	3.4	5.3	3.6
1984*	237.3	187.5	31.8	5.3	3.6	5.4	3.7
1985*	243.3	191.5	33.0	5.7	3.8	5.5	3.8
1986*	250.7	196.4	34.4	6.2	4.1	5.7	3.9
1987*	258.7	201.6	36.0	6.7	4.5	5.8	4.1
1988*	267.0	207.1	37.6	7.3	4.8	6.0	4.2

* Forecast.

Note--An active aircraft must have a current registration and have been flown during the previous calendar year. It should be noted that historical data are estimates.

Table 7

ESTIMATED ACTIVE GENERAL AVIATION AIRCRAFT BY FAA REGION

(In thousands)

As of January 1	Total	FAA Region										
		ANE	AEA	ASO	AGL	ACE	ASW	ARM	AWE	ANW	AAL	APC
1972	131.1	4.7	16.9	18.5	25.9	9.8	17.8	6.8	20.4	7.1	2.6	.3
1973	145.0	5.3	18.6	21.1	28.1	10.6	19.5	7.6	22.8	7.9	3.0	.3
1974	153.5	5.5	19.8	23.2	29.1	11.1	20.7	7.9	24.0	8.3	3.3	.3
1975	161.5	6.2	21.2	24.4	30.7	11.6	21.7	8.3	25.1	8.6	3.4	.3
1976	168.5	6.4	21.2	24.9	31.0	12.3	23.1	9.3	25.9	9.8	4.2	.4
1977*	181.6	6.9	22.8	27.0	32.8	12.9	26.3	9.8	27.7	10.4	4.6	.4
1978*	190.5	7.3	23.7	28.4	33.7	13.2	29.2	10.1	28.8	10.8	4.9	.4
1979*	196.9	7.6	24.3	29.4	34.2	13.3	31.9	10.2	29.4	11.1	5.1	.4
1980*	203.7	7.8	25.0	30.5	34.7	13.4	34.8	10.3	30.1	11.3	5.4	.4
1981*	213.3	8.2	25.9	32.0	35.5	13.6	38.5	10.6	31.1	11.7	5.7	.4
1982*	226.0	8.7	27.2	33.9	36.8	14.0	42.9	11.0	32.5	12.3	6.1	.5
1983*	233.5	9.0	27.8	35.0	37.2	14.0	46.7	11.1	33.1	12.5	6.4	.5
1984*	237.3	9.1	28.0	35.6	37.2	14.0	50.0	11.0	33.2	12.5	6.6	.5
1985*	243.3	9.3	28.4	36.4	37.3	14.1	53.8	11.0	33.6	12.6	6.8	.5
1986*	250.7	9.6	28.9	37.5	37.4	14.2	57.8	11.1	34.0	12.7	7.1	.5
1987*	258.7	9.9	29.4	38.5	37.5	14.2	62.5	11.2	34.5	13.0	7.4	.5
1988*	267.0	10.2	30.0	39.6	37.6	14.9	66.8	11.5	35.0	13.2	7.7	.5

* Forecast.

Note--Totals include a small number of aircraft located in foreign countries. Also see Table 6 footnotes.

TABLE 8

ESTIMATED HOURS FLOWN IN GENERAL AVIATION BY TYPE OF AIRCRAFT
(In millions)

Fiscal Year	Total	Fixed Wing				Rotorcraft	Balloons Dirigibles Gliders
		Piston		Turboprop	Turbojet		
		Single-engine	Multi-engine				
1972	26.4	19.4	4.3	1.0	0.5	1.0	0.2
1973	28.5	20.8	4.7	1.1	0.6	1.1	0.2
1974	31.3	22.5	5.2	1.2	0.8	1.3	0.4
1975	33.3	23.5	5.5	1.2	1.0	1.4	0.5
1976 1/	35.0	25.0	5.7	1.3	1.1	1.4	0.5
1977T*	9.5	6.7	1.5	.4	.3	.4	0.2
1977*	38.0	27.2	6.3	1.4	1.2	1.4	0.5
1978*	40.4	28.8	6.7	1.6	1.3	1.5	0.5
1979*	42.2	30.0	7.0	1.7	1.4	1.6	0.5
1980*	44.9	31.9	7.5	1.8	1.5	1.7	0.5
1981*	49.4	35.0	8.3	2.0	1.7	1.9	0.5
1982*	53.9	38.1	9.1	2.3	1.9	2.0	0.5
1983*	56.9	40.2	9.6	2.4	2.0	2.2	0.5
1984*	59.9	42.1	10.2	2.6	2.2	2.3	0.5
1985*	62.7	44.0	10.7	2.8	2.3	2.4	0.5
1986*	65.6	45.9	11.2	3.0	2.5	2.5	0.5
1987*	68.4	47.7	11.8	3.2	2.6	2.6	0.5
1988*	72.0	50.2	12.4	3.4	2.8	2.7	0.5

* Forecast. 1/ Preliminary.

Note--Detail may not add to total due to independent rounding. It should be noted that historical data are estimates.

1977T*--This represents the transition quarter, July 1, 1976, through September 30, 1976.

Table 9

ACTIVE U.S. MILITARY AIRCRAFT IN CONTINENTAL UNITED STATES (1)

As of June 30	Total	Fixed-Wing Aircraft			Helicopter
		Jet	Turboprop	Piston	
1972	20,745	9,634	1,086	3,376	6,649
1973	21,727	9,344	1,223	2,989	8,171
1974	21,143	9,091	1,207	2,854	7,991
1975	19,889	9,526	1,298	1,927	7,138
1976	20,023	9,162	1,298	1,619	7,744
1977*	19,953	9,403	1,373	1,457	7,720
1978*	19,786	9,340	1,422	1,251	7,773
1979*	19,547	9,315	1,436	1,048	7,748
1980*	19,605	9,450	1,428	1,007	7,720
1981*	19,808	9,632	1,428	996	7,752
1982*	20,098	9,843	1,432	997	7,826
1983*(2)	20,153	9,906	1,425	995	7,832
1984*	20,239	9,962	1,423	995	7,864
1985*	20,239	9,962	1,423	995	7,864
1986*	20,239	9,962	1,423	995	7,864
1987*	20,239	9,962	1,423	995	7,864
1988*	20,239	9,962	1,423	995	7,864

*Forecast

(1) Includes Army, Air Force, Navy and Marine regular service aircraft, as well as Reserve and National Guard aircraft.

(2) Detailed planning information not available beyond 1983. 1984-1988 projected at the 1983 level.

Source: Office of the Secretary of Defense, Department of Defense Liaison Officer to the Federal Aviation Administration.

Table 10

ESTIMATED FUEL CONSUMED BY UNITED STATES DOMESTIC CIVIL AVIATION

(In millions of gallons)

Fiscal Year	Total Jet Fuel and Aviation Gasoline	Jet Fuel			Aviation Gasoline		
		Total	Air Carrier	General Aviation	Total	Air Carrier	General Aviation
1972	8,724	8,311	8,037	274	413	22	391
1973	9,035	8,603	8,299	304	432	21	411
1974	8,534	8,071	7,714	357	463	20	443
1975	8,795	8,321	7,798	523	474	20	454
1976	8,922	8,403	7,831	572	519	20	499
1977T*	2,294	2,101	1,995	106	193	5	188
1977*	9,268	8,705	8,071	634	563	19	544
1978*	9,690	9,096	8,411	685	594	17	577
1979*	10,023	9,405	8,676	729	618	15	603
1980*	10,532	9,875	9,084	791	657	13	644
1981*	11,193	10,475	9,591	884	718	11	707
1982*	11,726	10,944	9,962	982	782	10	772
1983*	12,318	11,491	10,433	1,058	827	9	818
1984*	12,939	12,071	10,940	1,131	868	9	859
1985*	13,572	12,664	11,459	1,205	908	8	900
1986*	14,145	13,197	11,917	1,280	948	8	940
1987*	14,831	13,843	12,484	1,359	988	7	981
1988*	15,576	14,535	13,078	1,457	1,041	7	1,034

*Forecast.

Note--Domestic civil aviation is defined for purposes of the table to include all civil aircraft flights which originate and terminate within the 50 states. Fuel consumed by airframe and aircraft engine manufacturers, whether for flight testing or ground testing, are not shown here because they are not available for the domestic industry as a whole and cannot be estimated with any assurance of accuracy. Estimates of fuel consumed by the supplemental, contract and intrastate carriers are included in the "Air Carrier" columns. It should also be noted that general aviation fuel consumption is not reported and historical series are estimates.

1977T* represents the transition quarter, July 1, 1976 through September 30, 1976.

Table 11

TOTAL ITINERANT AND LOCAL AIRCRAFT OPERATIONS
AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE

(In millions)

Fiscal Year	Total	Itinerant	Local	Number of Towers
1972	53.6	33.6	20.1	348
1973	53.9	34.0	19.9	362
1974	56.8	36.1	20.8	394
1975	59.0	37.6	21.4	416
1976	62.5	39.7	22.8	428
1977T*	16.5	10.7	5.8	429
1977*	66.6	43.0	23.6	434
1978*	69.8	45.2	24.6	439
1979*	72.8	47.0	25.8	444
1980*	76.8	49.3	27.5	449
1981*	81.4	52.2	29.2	454
1982*	86.5	55.6	30.9	459
1983*	90.3	58.0	32.3	464
1984*	93.7	59.7	34.0	469
1985*	97.1	61.5	35.6	474
1986*	100.2	63.3	36.9	479
1987*	103.4	65.2	38.2	484
1988*	107.7	67.6	40.1	489

*Forecast

Note--An aircraft operation is defined as an aircraft arrival at or a departure from an airport with FAA traffic control service. A local operation is performed by an aircraft that: operates in the local traffic pattern or within sight of the tower; is known to be departing for or arriving from flight in local practice areas; or executes simulated instrument approaches or low passes at the airport. All aircraft arrivals and departures other than local (as defined above) are classified as itinerant operations. Detail may not add to total due to independent rounding.

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 12

ITINERANT AIRCRAFT OPERATIONS
AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE
(In millions)

Fiscal Year	Total	Air Carrier	Air Taxi	General Aviation	Military
1972	33.6	9.7	2.0	20.4	1.5
1973	34.0	9.8	2.1	20.6	1.5
1974	36.1	9.5	2.4	22.9	1.3
1975	37.6	9.4	2.8	24.2	1.3
1976	39.7	9.3	2.9	26.2	1.3
1977T*	10.7	2.4	.9	7.1	.3
1977*	43.0	9.7	3.5	28.6	1.2
1978*	45.2	9.9	3.9	30.2	1.2
1979*	47.0	10.2	4.2	31.4	1.2
1980*	49.3	10.5	4.5	33.1	1.2
1981*	52.2	10.9	5.1	35.0	1.2
1982*	55.6	11.1	5.3	38.0	1.2
1983*	58.0	11.4	5.4	40.0	1.2
1984*	59.7	11.7	5.7	41.1	1.2
1985*	61.5	12.1	6.0	42.2	1.2
1986*	63.3	12.5	6.3	43.3	1.2
1987*	65.2	12.8	6.6	44.6	1.2
1988*	67.6	13.2	6.9	46.3	1.2

* Forecast

Note--See Table 11 for definition of itinerant operations. Detail may not add to total due to independent rounding.

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 13

LOCAL AIRCRAFT OPERATIONS
AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE

(In millions)

Fiscal Year	Total	General Aviation	Military
1972	20.1	18.1	2.0
1973	19.9	18.1	1.8
1974	20.8	19.3	1.5
1975	21.4	20.0	1.4
1976	22.8	21.4	1.4
1977T*	5.8	5.5	.3
1977*	23.6	22.4	1.2
1978*	24.6	23.4	1.2
1979*	25.8	24.6	1.2
1980*	27.5	26.3	1.2
1981*	29.2	28.0	1.2
1982*	30.9	29.7	1.2
1983*	32.3	31.1	1.2
1984*	34.0	32.8	1.2
1985*	35.6	34.4	1.2
1986*	36.9	35.7	1.2
1987*	38.2	37.0	1.2
1988*	40.1	38.9	1.2

* Forecast

Note--See Table 11 for definition of local operations. Detail may not add to total due to independent rounding.

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 14

INSTRUMENT OPERATIONS AT AIRPORTS
WITH FAA TRAFFIC CONTROL SERVICE

(In millions)

Fiscal Year	Total	Air Carrier	Air Taxi	General Aviation	Military
1972	19.4	9.6	.9	5.0	3.9
1973	22.0 (1.5)	9.8	1.1	7.4	4.2
1974	24.1 (2.6)	9.5	1.4	9.2	4.0
1975	26.2 (2.9)	9.5	1.9	10.8	4.0
1976	28.1 (6.2)	9.5	2.2	12.8	3.7
1977T*	8.8 (2.6)	2.4	.6	4.8	1.0
1977*	30.9 (6.7)	9.8	2.2	15.3	3.6
1978*	33.3 (6.8)	10.0	2.4	17.4	3.5
1979*	35.0 (6.9)	10.3	2.5	18.7	3.5
1980*	36.7 (7.1)	10.6	2.6	20.0	3.5
1981*	38.9 (7.2)	11.1	2.7	21.6	3.5
1982*	40.2 (7.3)	11.4	2.8	22.5	3.5
1983*	41.6 (7.5)	11.6	3.0	23.5	3.5
1984*	43.0 (7.5)	11.9	3.1	24.5	3.5
1985*	44.5 (7.6)	12.3	3.3	25.4	3.5
1986*	46.2 (7.7)	12.7	3.5	26.5	3.5
1987*	47.8 (7.8)	13.0	3.7	27.6	3.5
1988*	49.6 (7.9)	13.4	3.9	28.8	3.5

*Forecast

Note--An instrument operation is defined as the handling by an FAA terminal traffic control facility of the arrival, departure, or over at an airport of an aircraft on an IFR flight plan or the provision of IFR separation to other aircraft by an FAA terminal traffic control facility. Non-IFR instrument counts at Terminal Control Area (TCA) facilities and Stage III of expanded area radar service are included in the totals and noted in parenthesis as an information item (see Table 15).

Includes instrument operations at FAA-operated military radar approach control facilities.

1977*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 15

NON-IFR INSTRUMENT OPERATIONS

(In millions)

Fiscal Year	Total	Terminal Control Areas - TCA's	Expanded Area Radar Service	
			Stage III As of 6/30/75	Stage III After 7/1/75
1972	-	-	-	-
1973	1.5	-	1.5	-
1974	2.6	-	2.6	-
1975	2.9	-	2.9	-
1976	6.2	1.7	3.7	.8
1977T*	2.6	.5	1.8	.3
1977*	6.7	1.8	3.8	1.1
1978*	6.8	1.8	3.8	1.2
1979*	6.9	1.8	3.9	1.2
1980*	7.1	1.9	3.9	1.3
1981*	7.2	1.9	4.0	1.3
1982*	7.3	1.9	4.0	1.4
1983*	7.5	2.0	4.1	1.4
1984*	7.5	2.0	4.1	1.4
1985*	7.6	2.0	4.1	1.5
1986*	7.7	2.0	4.2	1.5
1987*	7.8	2.1	4.2	1.5
1988*	7.9	2.1	4.2	1.6

*Forecast

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TCA count not available prior to 1976.

TABLE 16

IFR AIRCRAFT HANDLED
FAA AIR ROUTE TRAFFIC CONTROL CENTERS
(In millions)

Fiscal Year	Total			Aircraft Handled			
	Aircraft Handled	IFR Departures	Overs	Air Carrier	Air Taxi	General Aviation	Military
1972	22.0	8.5	5.1	12.4	.8	3.9	4.9
1973	22.8	8.9	5.1	12.6	.9	4.6	4.7
1974	22.9	9.0	4.9	12.4	1.1	5.1	4.3
1975	23.6	9.3	5.1	12.4	1.3	5.5	4.4
1976	23.9	9.4	5.1	12.4	1.4	6.0	4.2
1977T*	6.4	2.5	1.4	3.3	.4	1.6	1.1
1977*	25.7	10.2	5.3	13.1	1.7	6.9	4.0
1978*	26.7	10.6	5.5	13.4	1.9	7.6	3.9
1979*	27.7	11.0	5.7	13.7	2.1	8.1	3.9
1980*	28.9	11.5	5.9	14.0	2.3	8.8	3.9
1981*	30.7	12.3	6.1	14.5	2.5	9.9	3.9
1982*	32.1	12.9	6.3	15.0	2.7	10.6	3.9
1983*	32.9	13.2	6.5	15.3	2.9	10.9	3.9
1984*	33.9	13.6	6.7	15.6	3.3	11.2	3.9
1985*	35.0	14.1	6.8	16.1	3.5	11.6	3.9
1986*	36.3	14.6	7.1	16.7	3.7	12.1	3.9
1987*	37.7	15.2	7.3	17.2	3.9	12.8	3.9
1988*	39.2	15.8	7.6	17.8	4.2	13.4	3.9

* Forecast

Note--Detail may not add to total due to independent rounding. The aircraft handled count consists of the number of IFR departures multiplied by two plus the number of overs. This concept recognizes that for each departure there is a landing. An IFR departure is defined as an original IFR flight plan filed either prior to departure or after becoming airborne. An overflight originates outside the ARTCC area and passes through the area without landing. The forecast data assume present operating rules and procedures.

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

TABLE 17

IFR DEPARTURES AND OVERS
FAA AIR ROUTE TRAFFIC CONTROL CENTERS
(In millions)

Fiscal Year	Air Carrier		Air Taxi		General Aviation		Military	
	IFR Departures	Overs	IFR Departures	Overs	IFR Departures	Overs	IFR Departures	Overs
1972	4.6	3.2	.4	0	1.7	.6	1.8	1.4
1973	4.7	3.2	.4	0	2.0	.6	1.7	1.2
1974	4.6	3.1	.5	0	2.2	.7	1.6	1.1
1975	4.6	3.1	.6	.1	2.4	.7	1.6	1.2
1976	4.6	3.2	.7	.1	2.6	.8	1.5	1.1
1977T*	1.2	.9	.2	0	.7	.2	.4	.3
1977*	4.9	3.3	.8	.1	3.0	.9	1.5	1.0
1978*	5.0	3.4	.9	.1	3.3	1.0	1.4	1.0
1979*	5.1	3.5	1.0	.1	3.5	1.1	1.4	1.0
1980*	5.2	3.6	1.1	.1	3.8	1.2	1.4	1.0
1981*	5.4	3.7	1.2	.1	4.3	1.3	1.4	1.0
1982*	5.6	3.8	1.3	.1	4.6	1.4	1.4	1.0
1983*	5.7	3.9	1.4	.1	4.7	1.5	1.4	1.0
1984*	5.8	4.0	1.6	.1	4.8	1.6	1.4	1.0
1985*	6.0	4.1	1.7	.1	5.0	1.6	1.4	1.0
1986*	6.2	4.3	1.8	.1	5.2	1.7	1.4	1.0
1987*	6.4	4.4	1.9	.1	5.5	1.8	1.4	1.0
1988*	6.6	4.6	2.0	.2	5.8	1.8	1.4	1.0

*Forecast

1977*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 18

TOTAL FLIGHT SERVICES, PILOT BRIEFS
AND FLIGHT PLANS ORIGINATED
FAA FLIGHT SERVICE STATIONS AND COMBINED STATION/TOWERS

(In millions)

Fiscal Year	Total Flight Services	Pilot Briefs	Flight Plans Originated		
			Total	IFR-DVFR	VFR
1972	50.4	13.5	6.6	3.9	2.7
1973	53.7	14.7	7.2	4.5	2.7
1974	56.2	15.4	7.8	5.0	2.8
1975	58.3	16.2	8.0	5.2	2.8
1976	58.2	16.1	8.1	5.4	2.7
1977T*	16.5	4.7	2.2	1.4	.8
1977*	65.6	18.6	8.8	5.7	3.1
1978*	69.5	19.9	9.3	6.1	3.2
1979*	72.3	20.5	9.7	6.4	3.3
1980*	74.7	21.2	10.1	6.7	3.4
1981*	80.3	23.2	10.7	7.1	3.6
1982*	87.1	25.6	11.5	7.7	3.8
1983*	95.3	28.6	12.5	8.5	4.0
1984*	103.3	31.3	13.6	9.4	4.2
1985*	107.7	32.6	14.3	10.0	4.3
1986*	110.2	33.3	14.7	10.0	4.4
1987*	114.7	34.7	15.3	10.7	4.6
1988*	120.1	36.5	16.0	11.2	4.8

*Forecast

Note--Total Flight Services is a weighted workload measurement derived by multiplying pilot briefs and flight plans originated by two and adding the number of aircraft contacted. A flight plan may be filed orally or in writing to qualify for inclusion in the activity count. The data forecast in Tables 18 and 19 are based upon the current number and configuration of the FSS and CS/T. Any change in their number of operation would have a corresponding change on the forecast. Detail may not add to total due to independent rounding.

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 19

AIRCRAFT CONTACTED
FAA FLIGHT SERVICE STATIONS AND COMBINED STATION/TOWERS

(In millions)

Fiscal Year	Total	IFR-DVFR	VFR	Air Carrier	Air Taxi	General Aviation	Military
1972	10.0	1.4	8.6	.5	.6	8.2	.7
1973	9.9	1.5	8.4	.6	.7	8.0	.7
1974	9.9	1.5	8.4	.4	.7	8.1	.7
1975	10.0	1.6	8.4	.4	.8	8.1	.7
1976	9.8	1.5	8.3	.4	.8	8.0	.6
1977T*	2.7	.5	2.2	.1	.2	2.1	.2
1977*	10.8	1.9	8.9	.4	1.1	8.3	.6
1978*	11.1	2.1	9.1	.4	1.3	8.8	.6
1979*	11.9	2.2	9.7	.4	1.6	9.3	.6
1980*	12.1	2.4	9.7	.4	1.7	9.4	.6
1981*	12.5	2.5	10.0	.4	1.9	9.6	.6
1982*	12.9	2.7	10.2	.4	2.1	9.8	.6
1983*	13.1	2.8	10.3	.4	2.1	10.0	.6
1984*	13.5	2.9	10.6	.4	2.3	10.2	.6
1985*	13.9	3.1	10.8	.4	2.4	10.5	.6
1986*	14.2	3.2	11.0	.4	2.5	10.7	.6
1987*	14.7	3.3	11.4	.4	2.6	11.1	.6
1988*	15.1	3.5	11.6	.4	2.7	11.4	.6

*Forecast

Note--Aircraft contacted represent a record of the number of aircraft with which FAA facilities (FSS, CS/T) have established radio communications contact. One count is made for each en route, landing or departing aircraft contacted by a facility, regardless of the number of contacts made with an individual aircraft. A flight involving contacts with five different facilities, disregarding the number of contacts with each, would be counted as five aircraft contacted. Detail may not add to total due to independent rounding.

1977T*--This represents activity during the transition quarter, July 1, 1976, to September 30, 1976.

Table 20

ACTIVE PILOTS BY TYPE OF CERTIFICATE

As of January 1	Total	Students	Private	Commercial	Airline Transport	Helicopter	Glider	Instrument Rated (1)
1972	741,009	186,428	314,660	192,409	35,949	7,992	3,571	179,261
1973	750,869	181,477	323,383	196,228	35,949	7,987	4,080	187,909
1974	714,607	181,905	301,863	182,444	38,139	5,968	4,288	185,969
1975	730,541	180,795	305,848	192,425	41,002	5,647	4,824	199,323
1976	725,059	176,978	305,867	189,342	42,592	4,932	5,348	203,954
1977*	756,900	192,400	314,300	195,100	43,800	5,300	6,000	210,700
1978*	771,000	195,400	318,800	199,200	45,200	5,600	6,800	216,600
1979*	797,600	204,400	328,400	204,800	46,600	5,700	7,700	222,700
1980*	820,100	205,900	339,000	212,900	47,900	5,800	8,600	229,000
1981*	859,000	218,800	357,800	218,000	48,900	5,900	9,600	233,000
1982*	928,600	245,500	395,000	220,600	49,800	7,000	10,700	248,800
1983*	976,500	269,800	404,500	232,200	51,100	7,300	11,600	256,600
1984*	1,006,600	281,600	413,700	238,600	52,500	7,500	12,700	264,500
1985*	1,049,300	293,900	437,600	242,500	53,800	7,700	13,800	275,400
1986*	1,096,900	304,700	459,800	254,100	55,200	8,000	15,100	286,400
1987*	1,142,500	313,300	478,200	269,600	56,700	8,300	16,400	298,900
1988*	1,188,400	322,100	496,800	284,900	58,300	8,600	17,700	313,500

*Forecast (1) Not included in total

Note--The total count includes all pilots with current medical certificates; it also includes pilots who no longer fly but desire to keep their active status by periodic medical examinations. At the close of 1973 the active pilot count totalled 714,607, compared with 750,869 at the end of 1972. The decrease in the number of airmen resulted from a purging of the Airmen Certification files. During this process approximately 26,000 duplicates of faulty records were eliminated.

ALTERNATIVE ECONOMIC SCENARIOS

Long-term plans must anticipate changes in activity resulting from variations in economic conditions. The cumulative impact of various economic conditions can have a significant effect on planning in the long-term. In order to bracket the wide range of aviation activity levels which can be anticipated, two alternative projections have been made. See Table 21.

Our low scenario provides an indication of the path which the economy might take if recovery never fully occurs and a stagnant economy persists into the 1980's. As compared to the baseline economic assumptions, presented in the "Methods and Assumptions" section, the low scenario assumes real GNP grows at an average annual rate of 2.4 percent, unemployment averages about 6.7 percent, and the inflation rate hovers around 6.1 percent. This scenario represents a 1.9 percent decrease in civilian employment, a 3.7 percent decrease in real personal disposable income per capita, and a 2.1 percent decrease in investment from the corresponding values assumed in the baseline forecast.
(Text continued on page 70)

TABLE 21

LONG TERM FORECAST FOR 1988

	LOW SCENARIO	HIGH SCENARIO
Scheduled Domestic Passenger Traffic		
Revenue Passenger Miles (Billions)	258.4	346.3
Revenue Passenger Enplanements (Millions)	356.4	466.0
Fleet Size		
Air Carrier	3,150	4,033
General Aviation	258,100	273,400
Hours Flown (Millions)		
Air Carrier	7.8	9.79
General Aviation	67.8	75.0
Tower Operations (Millions)		
Total	102.2	113.0
Itinerant	74.3	70.5
Air Carrier	12.8	14.4
Air Taxi	6.6	7.1
General Aviation	44.7	47.8
Military	1.2	1.2
Local	36.9	42.5
General Aviation	35.7	41.3
Military	1.2	1.2
Instrument Operations (Millions)		
Total	47.9	53.7
Air Carrier	12.9	14.6
Air Taxi	3.7	4.1
General Aviation	27.8	29.7
Military	3.5	3.5
IFR Aircraft Handled (Millions)		
Total Handled	37.1	41.4
Total Departures	15.0	16.8
Total Overs	7.1	7.8
Air Carrier Handled	17.1	19.4
Air Taxi Handled	4.0	4.4
General Aviation Handled	12.2	13.8
Military Handled	3.8	3.8
Flight Services (Millions)		
Total	112.9	124.4
Pilot Briefs	34.0	37.8
Flight Plans Originated	15.1	16.6
Aircraft Contacted	14.7	15.6

The high scenario assumes an annual average growth in real GNP of about 4.8 percent, average inflation rates around 5.0 percent, and unemployment rates around 4.5 percent. On average, this outlook represents an increase of 1.3 percent in civilian employment, an increase of 1.9 percent in real personal disposable income per capita, a decrease of about 1.5 percent in the inflation rate, and a 5.6 percent increase in investment over the corresponding values assumed in the baseline forecast.

APPENDIX A

NATIONAL FORECAST OF TOTAL GENERAL AVIATION OPERATIONS AT TOWERED AND NONTOWERED AIRPORTS

Systems Consultants, Inc.
James W. Hines, FAA, Contract Technical Officer

For the first time, operation forecasts for the entire general aviation community including activity estimates for both airports with Federal Aviation Administration (FAA) traffic control service and at all the other airports of record are included in this appendix.

The forecasts and referenced base data estimates shown in Appendix A have been taken from two reports accomplished by Systems Consultants, Inc. (SCI) under FAA contract management:

(1) Report No. FAA-AVP-76-6, Nationwide, Regional and Statewide Estimates for General Aviation (GA) Activity at Nontowered Airports During CY 1972 (Revised) and CY 1974

(2) Report No. FAA-AVP-76-7, General Aviation Forecasts, 1975-1987, State, Regional and National Operations

The reports consist of the results of the Office of Aviation Policy, Aviation Forecast Branch's first formal investigation of the extent of total general aviation on a nationwide basis using aircraft operations at both tower and nontower airports as the unit of measure. Both reports can be obtained through the National Technical Information Service, Springfield, Virginia 22161, or by contacting the Office of Aviation Policy for any available copies in stock.

The national forecasts presented in Appendix A and the other general aviation base data estimates and forecasts in the above reports are not to be considered at this time as official FAA

estimates of general aviation air traffic activity. However, the 1972 and 1974 estimates and the 1975-1987 forecasts of total tower plus nontower activity now offer a total picture of aviation operations to correspond with the total general aviation fleet and hours flown. As such, the estimates are considered to be reliable and statistically accurate and will assist in developing future analyses of this segment of the aviation industry.

Yearly data for total, local, and itinerant operations are shown in Table A-1. In the subsequent 5 and 10 year periods, nationwide general aviation tower plus nontower airport operations are forecast to increase 22 percent by 1979 and 52 percent by 1984, from a reference level of 125.7 million operations in 1974. It is estimated that 200 million aircraft operations will take place in 1985. At that time, an estimated 88.6 million itinerant operations will represent approximately 44 percent of the total, a slight percentage decrease from the 1974 level of 46 percent. By 1987, nationwide total tower plus nontower operations are expected to be 77 percent greater than 1974.

TABLE A-1 NATIONAL FORECAST OF TOTAL GENERAL AVIATION OPERATIONS AT TOWERED AND NONTOWERED AIRPORTS 1/

(In millions)

CALENDAR YEAR	TOTAL OPERATIONS	LOCAL OPERATIONS	ITINERANT OPERATIONS
1972 2/	115.4	63.8	51.6
1974 2/	125.7	67.9	57.8
1975	130.7	70.2	60.5
1976	135.4	72.9	62.5
1977	141.2	76.4	64.8
1978	146.8	80.7	66.1
1979	153.4	84.5	68.9
1980	157.6	87.3	70.3
1981	163.6	90.7	72.9
1982	171.5	95.1	76.4
1983	180.8	100.3	80.5
1984	190.6	105.9	84.7
1985	200.4	111.8	88.6
1986	211.6	118.4	93.2
1987	222.5	125.0	97.5

1/ Taken from Report No. FAA-AVP-76-7

2/ Estimates from Report No. FAA-AVP-76-6

APPENDIX B

MACRO AIR CARRIER FORECASTING MODEL

Jonathan C. Tom

July 19, 1976

The expected use of the FAA air traffic system by the air carriers depends primarily on the amount of passenger traffic handled by the carriers and on the operating behavior of the airlines. This paper discusses a model which describes the historical relationships between economic and aviation activity. These relationships extrapolated into the future form the basis for passenger and air carrier aircraft operations forecasts. The model structure and the variables used in the model are reviewed first. Next is a discussion of the statistical results. The assumptions which form the basis of the forecasts are discussed in the third part.

The Model

Demand for air transportation services is expected to be related to price, income, population, and quality of air carrier service. In addition to airline operating constraints such as the load factor required to maintain profitability, this demand determines the number of air carrier flights. To describe these relationships, the following model has been developed.

1. RPM = f (SRVC, PAT, REL, TQR, STR)

2. ENP = g (CMP, PAT, REL, TQR, STR)

3. OPS = h (RPM, LOAD, SEATS, STAGE)

Equations 1 and 2 are linear relationships, while equation 3 is an identity relating RPM to OPS. Note that the two measures of demand have different specifications. Since the number of enplanements is limited by the number of people able to fly, CMP is the appropriate variable. Since the distance flown is limited by income rather than population, on the other hand, SRVC should be used to explain RPM.

The variables endogenous to the model are:

1. RPM - Scheduled domestic revenue passenger miles are used to reflect overall demand for air travel. An RPM is counted when a paying passenger flies one mile. The data were computed as quarterly totals and include scheduled activity from all certificated domestic route air carriers. The data are in billions of RPMs.

2. ENP - Another measure of demand for air travel is scheduled domestic revenue passenger enplanements. Also computed on a quarterly basis, this variable reflects millions of passengers boarding scheduled domestic flights.

3. OPS - Air carrier itinerant aircraft operations at airports with FAA air traffic control service reflect the usage of FAA facilities. These data count thousands of landings and takeoffs by aircraft serving the certificated airlines.

The exogenous variables which impact demand are:

1. SRVC - Because the use of air transportation is the consumption of a service, income used for the personal consumption of services can be used to represent the effect of income on demand. SRVC should then be positively related to RPM. These data are in billions of 1972 dollars and are annualized and deseasonalized.

2. CMP - The number of civilians employed reflects that portion of the population which may use air carrier services. As the level of CMP increases so should the level of ENP. These data are in millions of people.

3. PAT - This variable measures plant, equipment, and other investment in the air transport industry. Given that such investment leads to an improvement in the quality of air transportation service, PAT should be positively related to demand. These data are in billions of current dollars and are annualized and deseasonalized.

4. REL - The price of air transportation relative to that of other modes of transportation should have a negative impact on demand. As air fares decline relative to the cost of automotive transportation, the quantity of service demanded will increase. REL then is a ratio between a price index for adult coach fares and an index for the cost of private transportation. Both of these indexes are based on 1967 dollars.

5. TQR - Demand for air carrier services is seasonal in that the third quarter of each year is a popular vacation period. This impact is represented by the dummy variable TQR and is expected to be positive. TQR is one for the third quarter of each calendar year and zero for all others.

6. STR - This dummy variable is used to estimate the effect of major airline strikes on the demand for air travel. The period most affected by a strike was the third quarter of 1966. The variable is one during this period, and zero otherwise.

The exogenous inputs to the aircraft operations identity are the average load factor (LOAD), the average number of seats per aircraft (SEATS), and the average stage length (STAGE). These variables represent data for scheduled domestic certificated route air carriers. The average load factor represents the percentage of available seat miles filled during the recording period. The average stage length is in miles. The specific identity used is:

$$\text{OPS} = 2 * \frac{\text{RPM}}{\text{LOAD} * \text{SEATS} * \text{STAGE}} \qquad (4.)$$

Other variables such as real gross national product, total population, the index for industrial production, and average yield were also considered. Because these variables did not improve the explanatory capabilities of the models, they were not used.

The structure of the models is substantially unchanged from the 1975 version. Substituting TQR for automobile purchases was the only alteration. The use of this dummy variable enables the model to explain the seasonal behavior of demand for air transportation.

Statistical Results

An ordinary least squares regression technique was used to estimate equations 1 and 2. The relationship between the endogenous and exogenous variables was assumed linear for both measures of demand. The linear form reflects the behavior of a mature industry whose growth is now dependent on general economic growth rather than the discovery of new markets. The estimated equations are:

$$\text{Estimated ENP} = -76.05 + \underset{(22.6)}{1.59} * \text{CMP} + \underset{(4.61)}{2.24} * \text{PAT} \underset{(-1.93)}{-0.16} * \text{REL} + \underset{(4.61)}{2.94} * \text{TQR} \underset{(-3.51)}{-6.87} * \text{STR}$$

Corrected R-squared = 0.960
Durbin-Watson Statistic = 1.512
Standard Error = 1.845

$$\text{Estimated RPM} = -18.19 + \underset{(25.27)}{0.16} * \text{SRVC} + \underset{(5.303)}{1.74} * \text{PAT} \underset{(-1.66)}{-0.10} * \text{REL} + \underset{(7.388)}{3.21} * \text{TQR} \underset{(-3.48)}{-4.18} * \text{STR}$$

Corrected R-squared = 0.969
Durbin-Watson Statistic = 1.631
Standard Error = 1.260

The numbers in parentheses are Student t-statistics corresponding to each coefficient. Note that all coefficients are of expected sign, substantiating the *a priori* hypotheses. The corrected R-squares indicate that the models explain over 95 percent of the variance in the dependent variables. The Durbin-Watson statistics indicate that serial correlation is not significant at a 1 percent level. Therefore, these models do explain the historical demand for air carrier services. Given that the estimated relationships continue into the future, the equations can be used for forecasting.

Forecast Assumptions

Economic forecasts from the Wharton Econometric Forecasting Associates, Inc., are the source of the economic assumptions used in this forecast. The baseline scenario assumes in general that the high growth rates of economic recovery will continue into 1977. Thereafter, the economy as measured using gross national product (GNP) is expected to stabilize at a per annum growth rate of about 3.3 percent.

Accompanying economic recovery will be a trend of consumers to shift from consumption of durable goods to services. As consumers complete their purchases of durables (purchases postponed during the recession) during 1976, personal consumption of services will increase at a 4.2 percent rate per year through 1980. During the 1980's after the economy stabilizes, consumption of services is expected to increase at approximately the same rate as GNP.

Likewise, changes in the number of persons employed will parallel the economic recovery. While the employed population is expected to increase at a 3.6 percent growth rate during the recovery years of 1976 and 1977, the long-term trends will follow the growth in population of about 1.6 percent per year.

The combined impacts of personal expenditures on services and the employment trends contribute to the relatively higher growth of demand for air transportation through 1980 and the decrease in this growth rate during the 1980's. The forecasts of air transportation investment and the relative price of air transportation vis-a-vis automotive travel further modify these impacts.

The cost of fuel will continue to influence the level of air fares through the forecast period. However, because of the 55 miles per hour speed limit and because of the historical trends in jet fuel and automobile gasoline prices, air fares are expected to decrease relative to the cost of automobile travel. This phenomenon is expected to have a positive impact on the demand for air transportation. Similarly, increases in the quality of service as represented by investment in air transportation are expected in the future.

In addition to these economic assumptions, some assumptions about airline behavior were made. Because of continuing increases in operating costs, the air carriers will attempt to remain profitable by maintaining a load factor which will increase gradually to approximately 58 percent during the forecast period. Consistent with higher future costs, airlines are expected to increase their use of wide-body aircraft. In the face of continuing high costs, this policy will enable the airlines to increase the number of seats flown on each market, while maintaining aircraft operating frequencies and reducing costs per seat-mile. Finally, the substitution of commuter service in some short-haul markets and the introduction of more nonstop service are expected to cause the average stage length to increase gradually during the forecast period.

APPENDIX C

GENERAL AVIATION FORECASTING MODEL

Stephen G. Vahovich and Jonathan C. Tom

July 1976

I. INTRODUCTION

Significant growth in the size of the general aviation fleet during the sixties, and the relatively recent trend toward larger multiengine and turbine powered fixed wing aircraft, have lead to increased intensity of use of the National Aviation System (NAS) by general aviation aircraft. The effect of increased fleet size and the trend toward larger general aviation aircraft are reflected in the increase in general aviation operations (takeoffs and landings) at Federal Aviation Administration (FAA) towered airports--between 1959 and 1972 general aviation operations almost tripled in size (growth in air carrier operations over the same period was only 32 percent), and general aviation currently accounts for over 80 percent of total aircraft operations at towered airports in the United States. Since general aviation represents such a significant component of NAS activity, forecasts of general aviation activity are critical measures of future demands on the NAS. Thus, the forecasting model presented in this paper represents an important basis for aviation planning purposes.

The structure of this paper is as follows: Section II discusses the model and relevant economic hypotheses; Section III presents the empirical results; and Section IV discusses the general economic assumptions upon which the forecasts are based.

II. MODEL AND HYPOTHESES

The fundamental assumptions underlying the general aviation model are that the various measures of general aviation activity are related to the level of economic activity, and that the various activity measures are dependent on one another in a specific (i.e., without feedback) way. The

latter assumption accounts for the construction of the model as a recursive system (see Johnston, Econometric Methods, p. 377) and justifies the estimation technique

Figure A incorporates these assumptions and illustrates the general structure of the model. Figure B defines the endogenous and exogenous variables in the model, and Figure C presents the system of equations summarizing the behavioral assumptions included in the model. Since the same exogenous variable may appear in more than one equation, with the same expected sign, the following detailed discussion of the associated behavioral hypothesis is presented with respect to all relevant endogenous variables.

By the *a priori* reasoning presented below the signs of the parameter estimates of all the exogenous variables, except TVARIND and SUB, are expected to be positive. Because aircraft and pilots are primary inputs into the use of National Aviation System, GAAA and STD are estimated directly, that is, as functions of economic variables only. An increase in the portion of the population likely to purchase and use aircraft (CMP) is likely to increase GAAA. SUB is used as a measure of the use of automobile travel. Assuming automobiles and aircraft represent, to some extent, substitute modes of transportation; for a given budget, the more widespread the use of automobile transportation (SUB) the fewer GAAA. LIPAC, a surrogate measure for previous year aircraft orders, is expected to reflect the positive effect on GAAA of the annual increment to the active GA fleet stemming from new aircraft. The lag is used to account for the assumed one period delay between orders and the finished product.

LIPAC serves a dual role because increases in plant and equipment expenditures are likely, to a certain extent, to reflect quality (e.g., as manifested in improved safety of GA flying) related improvements in aircraft design or avionics as well as the impact of consumer acceptance of GA flying. As such, LIPAC is expected to be useful in explaining the hypothesized positive effect of these factors on STD. To account for the income effect on student pilots, PPDPI is included. Since increases in the variable costs of flying are likely to reduce student starts and training flights, TVARIND is expected to have a negative parameter estimate in the STD equation.

(Text continued on page 86)

FIGURE A
General Aviation Forecasting Model

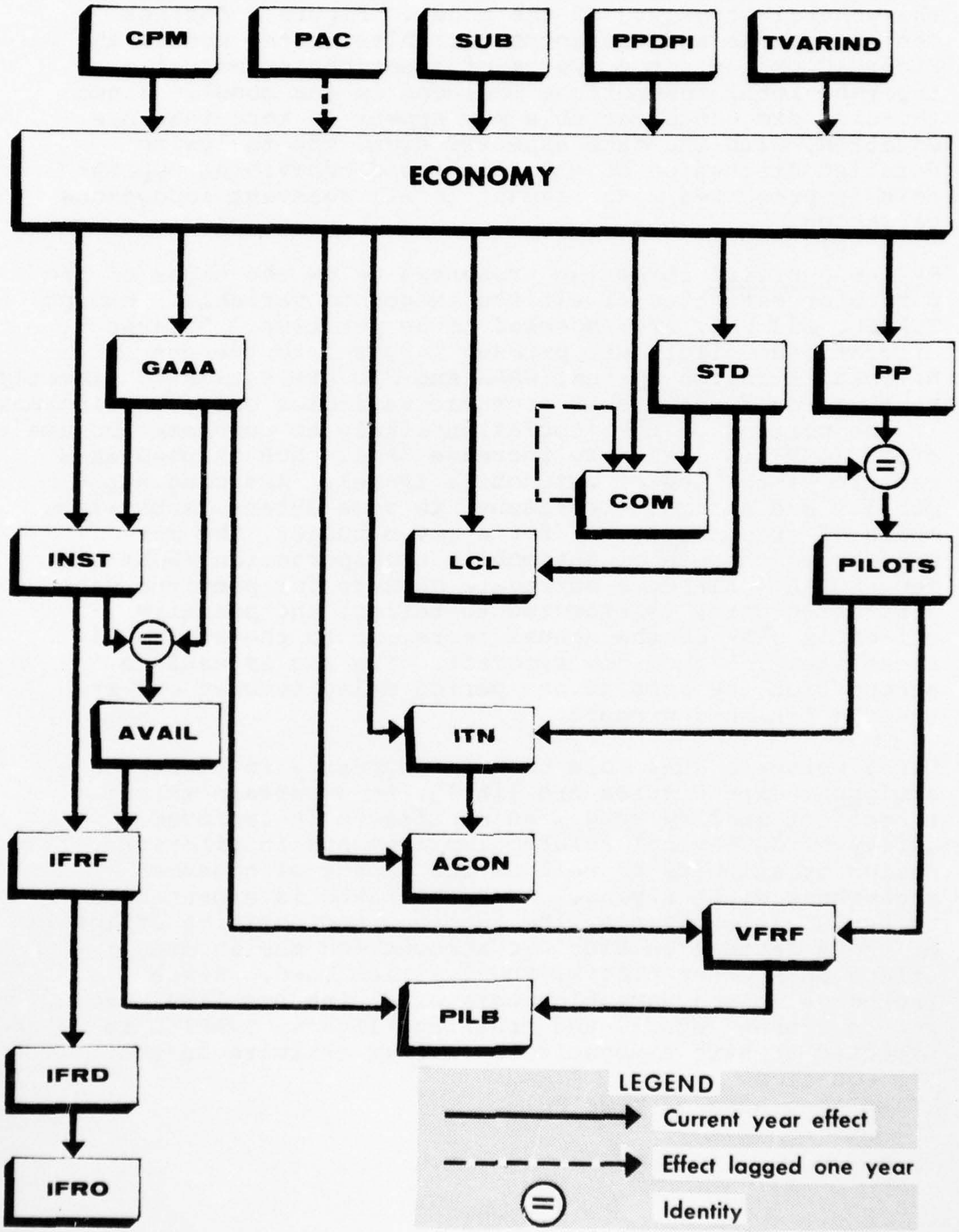


Figure B: Endogenous and Exogenous Variables in the Model

Endogenous Variables	Definition
GAAA	Number of general aviation aircraft
PP, STD, INST	Number of active private, student, and instrument rated pilots, respectively
COM	Sum of the number of active private and commercial pilots
ITN, LCL	Number of itinerant and local operations, respectively. General aviation and air taxi operations are included in these measures of activity at airport traffic control towers
IFRD, IFRO	Number of instrument flight rule (IFR) departures and over flights, respectively. General aviation and air taxi operations are included in these measures of activity at air route traffic control centers
IFPF, VFPF	Number of IFR and visual flight rule (VFR) flight plans filed
POLB	Number of pilot briefs
ACON	Number of aircraft contacted. General aviation, air taxi, air carrier, and military are included in this measure of activity at flight service stations
INSTOP	Number of instrument operations. General aviation, air taxi, air carrier and military are included in this measure of activity at airports with FAA control service

Exogenous Variables	Definition
CMP	Number of civilians employed
LIPAC	Plant and equipment expenditures in aircraft industry lagged by one period
SUB	Factory sales of automobiles
PPDPI	Per capita disposable personal income in constant 1972 dollars
AVAIL	Ratio of the number of general aviation aircraft to the number of instrument rated pilots (estimated)
PILOTS	Sum of active student and private pilots (estimated)
CLEAN	Equal to 1 if year is 1973 or greater
TVARIND	Laspeyre total variable cost index, 1972 base year

Figure C: General Aviation Forecasting Model*

GAAA = f (CMP, LIPAC, SUB)

STD = f (PPDPI, LIPAC, TVARIND)

PP = f (STDE, PPDPI, CLEAN)

COM = f (STDE, LICOM)

LCL = f (STDE, PPDPI)

ITN = f (PPDPI, PILOTS)

VERF = f (GAAAE, PILOTS)

INST = f (GAAAE, TVARIND)

IFRF = f (INSTE, AVAIL)

IFRD = f (IFRFE)

IFRO = f (IFRDE)

ACON = f (ITNE, TVARIND)

PILB = f (VFRFE, IFRFE)

* The prefix "LI" indicates a one period lag, and the suffix "E" indicates that the estimated value of the variable is used as an independent variable.

Beginning the first level of structural dependence, the hypothesized positive sign for estimated student pilots (STDE) in the COM and PP equations is accounted for by the fact that commercial and private pilots are initially drawn from the student pilot pool. Similarly, the nature of LCL (primarily consisting of training and pleasure flights) accounts for the hypothesized positive parameter estimate of STDE in the LCL equation. PP and LCL are also expected to be influenced directly through PPDPI--the income effect. For 1973 data, the airman file was purged such that duplicate records were eliminated. For example, prior to 1973 a pilot may have been recorded on file as holding both a private and a commercial pilot rating, the 1973 purge and all subsequent updates to this file would count this pilot only as a commercial pilot. Since the effect of this purge is to reduce the previously artificially-inflated count in each of the various pilot classifications, CLEAN is expected to be negatively related to PP.

The autoregressive hypothesis relating LICOM and COM emphasizes the role of expectations held last period by the then existing commercial and private pilot complement. That is, the current number of commercial and private pilots depends on the decisions made by these pilots in the preceding year (e.g., whether or not to remain active). The lapse in time between such decisions and their market impact is accounted for by the assigned one period lag. It is important to include commercial pilots because available data for the number of instrument rated pilots (INST) does not distinguish by pilot certification.

VFRF is estimated as a function of the estimated number of GA aircraft (GAAAE). Presumably the greater the number of active aircraft the larger VFRF. Since student and private pilots (PILOTS) are most likely to fly VFR, the greater the number of these pilots, the greater the expected number of VFRF. In addition to the expected positive effect of PILOTS, itinerant operations (ITN) may be expected to increase as income increases. Thus far, the recursive structure has been described through one level, namely, the impact of GAAAE and STDE on PP, COM, LCL, ITN and VFRF. The latter group of variables, however, continue the one-way dependence to other measures of NAS activity. Similar to the above reasoning, increases in the number of

active aircraft are likely to be associated with higher values for INST, while increasing variable cost is likely to result in fewer instrument operations.

The hypothesized positive effect of ITNE in the ACON equations is accounted for by the fact that itinerant operations are likely to involve flights passing over at least one ARTCC, and such flights are likely to entail considerable contact with FSS's for weather and other flight condition information. IFRO is expected to be positively affected by the number of IFR departures (IFRDE), and ACON is expected to be negatively influenced by increases in FUEL--inverse price-quantity demanded relationship. The availability of aircraft to instrument rated pilots, as measured by the number of aircraft per instrument rated pilot (AVAIL), is expected to be positively related to the number of IFR flight plans filed. Independent of the effect of availability, the number of instrument rated pilots is expected to be positively related to IFRF. The latter is clearly evident for the case where the ratio remains constant--e.g., due to a proportional increase in aircraft and instrument pilots--from year to year but an increase in IFRF is also likely because of an increase in INSTE.

Finally, estimated IFR flight plans filed (IFRFE) is used to explain IFRD and PILB. For the IFRD equation, the hypothesized positive parameter estimate is based on the fact that IFR flight plan filings are required for IFR departures. VFRFE and IFRFE are hypothesized to have a positive effect in the PILB equation because the intent to fly is established through the filing of a flight plan, and since weather and other flight condition information is essential to any flight, an increase in IFRFE or VFRFE is likely to result in an increase in PILB.

The discussion of the structure of the model and the behavioral hypotheses is concluded. The following section addresses the empirical results derived from the model presented in Figure D.

III. EMPIRICAL RESULTS

Figure D presents the estimated GA model. Numbers in parentheses are the associated t-statistics. The historical data are on an annual basis covering the period 1960 through 1975. All equations in the model are estimated using the ordinary least squares estimating procedures.

Figure D: Estimating Equations for the General Aviation Forecasting Model*

							Durbin-Watson	Corrected R-square
GAAA =	-89.96	+ 43.59	CMP	+ 46.46	LIPAC	- 0.02 SUB	1.86	.99
		(34.71)		(1.29)		(-2.58)		
STD =	-203.57	+ 1.18	PPDPI	+ 86.15	LIPAC	- 1.04 TVARIND	2.16	.92
		(5.67)		(5.97)		(-3.25)		
PP =	-279.60	+ .45	STDE	+ 1.37	PPDPI	-48.33 CLEAN	1.61	.98
		(3.11)		(8.94)				
COM =	- 0.12	+ .71	LICOM	+ .79	STDE		2.51	.98
		(8.41)		(3.23)				
LCL =	-134.75	+ 0.90	STDE	+ 0.41	PPDPI		1.65	.96
		(6.71)		(3.64)				
ITN =	-185.98	+ 0.86	PPDPI	+ 0.20	PILOTS		1.05	.96
		(4.79)		(2.49)				
VFRF =	577.73	+ .66	GAAAE	+ 2.41	PILOTS		1.19	.86
		(1.85)		(2.43)				
INST =	-78.73	+ 0.208	GAAAE	- 0.41	TVARIND		1.42	.97
		(7.82)		(-1.52)				
IFRF =	-6752.16	+ 39.28	INSTE	+ 4.80	AVAIL		1.09	.94
		(6.51)		(2.32)				
IFRD =	-53.60	+ 0.71	IFRFE				1.70	.98
		(26.14)						
IFRO =	58.60	+ 0.25	IFRDE				2.56	.99
		(32.10)						
ACON =	561.44	+ 2.43	ITNE	- 1.41	TVARIND		1.60	.90
		(5.64)		(-1.60)				
PILB =	-1294.17	+ 0.71	VFRFE	+ 0.18	IFRFE		1.80	.99
		(6.96)		(5.12)				

**INSTOP = a+b ITN + MILITN

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* The units utilized are as follows: GAAA in hundreds; PP, STD, INST, COM, IFRD, IFRO, IFRF, and VFRF in thousands; ITN, LCL and SUB in hundred thousands; PILB and ACON in ten-thousands; CMP in millions; LIPAC in billions of current dollars; PPDPI in tens-of constant 1972 dollars.

** This equation is an identity.

The results presented in Figure D are consistent with conventional economic theory. Without exception, the signs of the parameter estimates are as hypothesized in Section II and the Durbin-Watson statistics suggest that, with the exception of three equations in the undecided range, there is no significant (.99 level) positive or negative first-order autocorrelation. All but two of the parameter estimates are significant at least at the .90 level of significance (t-test) and the large majority are significant at the .99 level. The corrected R-squares, indicating the amount of variance in the dependent variable explained or accounted for by the independent variables adjusted for the degree of freedom are quite respectable.

Since the interpretation of the estimated coefficients is relatively straightforward and because of space limitations, interpretation of the particulars of the estimating equations is left to the reader.

The instrument operations equation (INSTOP) in Figure D is an identity. The parameter a varies between 3.5 and 3.7 over time, and is intended to account for expected increases in the number of airport towers becoming stage-three control areas--pilots flying into Stage III control areas must fly IFR. The parameter b varies between .32 and .49 over time, and is intended to account for the expected increase in the level of pilot sophistication. That is, it accounts for the effect of increases in the number of instrument rated pilots and the increased use of avionics. The variables, ACITN, ITN, and MILITN represent the number of air carrier, air taxi and general aviation, and military itinerant operations, respectively.

IV. ASSUMPTIONS FOR FORECAST YEARS: 1976-88

Assumptions as to the future levels of the economy are from forecasts developed by Wharton Econometric Forecasting Associates, Inc. The "Methods and Assumptions" section, presented earlier, gives the general economic outlook and discusses expected movements in two specific economic variables (CMP and PPDPI) used in the general aviation forecasting model. As to the expected course for the remaining exogenous variables, investment in the aircraft industry (LIPAC) is expected to increase at an annual average rate of about 12.0 percent, automobile sales (SUB) at 3.2 percent, and aircraft variable cost (TVARIND) at 4.8 percent. The investment path assumptions are comparable to Wharton's forecasted investment in nonauto transportation equipment, and variable cost changes follow Wharton's forecasted rates of change in the price of gasoline and oil.

APPENDIX D*

HOW TO FORECAST AVIATION ACTIVITY LEVELS

Stephen G. Vahovich

July 1976

I. INTRODUCTION

This appendix is intended to provide more detailed information to the interested public on the approach that is utilized to generate the aviation activity forecasts. The technique described below has been used to arrive at this year's national activity forecasts. It may also be viewed as a useful tool to arrive at activity forecasts on the regional, state, or airport level of disaggregation--assuming data or other limitations are overcome. A basic knowledge of econometric methodology and nomenclature is assumed on the part of the reader.

Since the discussion focuses on operations levels, a few definitions are valuable. Local operations are defined as operations which are at all times within view of the airport tower, within the local traffic pattern, which remains in the local practice areas within a twenty-mile radius of the control tower, or which execute simulated instrument approaches or low passes at the airport. All other operations are by definition itinerant operations. Instrument operations may be either itinerant or local; they are operations conducted in accordance with Instrument Flight Rule (IFR) flight plans and other operations in which aircraft are provided IFR flight separation from other aircraft by terminal air traffic control facilities.

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* Since the final responsibility for all official FAA aviation forecasts rests with the Office of Aviation Policy, this appendix should not be construed to in any way delegate or relinquish any part of that responsibility.

II. SHORT RANGE FORECASTING USING TREND ANALYSIS

Short range forecasting (within one year) of itinerant, local, and instrument operations may be accomplished using trend analysis or econometric models (described in Section III). Trend analysis assumes that recent past periods are the best predictors of the immediate future. Thus, forecasts are obtained solely from the historical values of the variable to be forecasted. This type of modeling ranges from the very simple to more complex models.

A. Simple Trend Analysis. There are several ways of incorporating trends in forecasts.

(1) An average of past absolute changes may be used to incorporate trends in forecasts:

$$\hat{X}_{t+1} = X_t + \frac{\sum_{i=0}^{n} \left[X_{t-1} - X_{t-(i+1)} \right]}{n+1} \tag{2-1}$$

Where X stands for the variable to be forecast, the subscript t refers to the period of time involved, and the circumflex (∧) identifies a forecast value as distinguished from an observed datum. The n is the arbitrarily chosen number of changes averaged, and i is the sequential index (i assumes all integer values from 0 through n). For example, if we wish to forecast itinerant operations for January 1976 and the historical series for this data are given in Table D-1, the forecast is obtained as follows.

Table D-1: Itinerant Operations

Month	1974	1975
January	323	349
July	473	512
August	554	600
September	544	589
October	374	400
November	305	350
December	299	310

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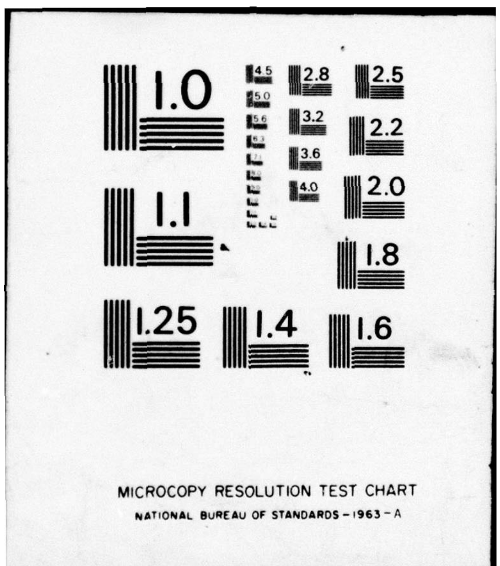
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

For n = 2, using equation (2-1) the computation is:

$$\hat{X}_{t+1} = 310 + \frac{(310-350)+(350-400)+(400-589)}{3}$$

$$= 310 + \frac{(-40-50-189)}{3} = 310-93$$

$$= 217 \text{ operations}$$

(2) An average of past absolute change or rates of change may be used to incorporate trends in forcasts, according to:

$$\text{(2-2)} \quad \hat{X}_{t+1} = X_t \left[\sum_{i=o}^{n} \frac{X_{t-i}}{X_{t-(i+1)}} \right] \frac{1}{n+1}$$

For example, using the data from Table 1, for n=2 the forecast is:

$$\hat{X} = 310 \quad \frac{\frac{310}{350} + \frac{350}{400} + \frac{400}{589}}{3}$$

$$= 310 \quad \frac{.8857+.8750+.6791}{3}$$

$$= 310 \quad \frac{2.4398}{3} = 252 \text{ operations}$$

In the preceding two examples, forecasted operations for January 1976 are lower than those experienced during December 1975, or during January 1975. This is because the number of operations for December 1975 and for the three (n+1=3) immediately preceding months were decreasing monotonically. That is, the example data shows that operations during 1975 peaked-out during August, and then declined continually for each succeeding month. This peak-trough pattern within one year is commonly referred to as a seasonal variation, and it is not accounted for in the preceding two forecasting techniques. Had the number of operation from September through December 1975 been continually increasing (i.e., no seasonality), the techniques illustrated in equations (2-1) and (2-2) would have resulted in a higher forecasted level of operations for January 1976 than observed for December 1975.

Thus, the present examples are double-edge in that they illustrate the mathematical technique for particular forecasting tools, but they also show the danger of not accounting for seasonality when it is present. The following section presents a method to incorporate seasonal variations into the forecasts.

B. <u>Accounting for Seasonal Fluctuations in Trend Analysis</u>.

Seasonal variations can be described as within-year fluctuations in the data which occur with some consistency over time. These fluctuations may be due to such things as weather conditions, calendar events, tradition, etc., and may strongly influence activity levels. Table D-1 shows that operations reach their lowest level during December of each year and that they rise again for January, and that despite the seasonal fluctuations, operations are growing (1975 monthly levels of operations exceed their corresponding monthly level for 1974) over time. Trend analysis may be used to combine the seasonality and trend factors as given in the following example.

(2-3) $$\hat{X}_{t+1} = X_{t-11} * 12 \left[1 - \left\{ \frac{X_t \left[X_{t-13} \right]}{X_{t-1} \left[X_{t-12} \right]} \right\} \right]$$

For example, using the data from Table 1, the forecast is:

$$\hat{X}_{t+1} = 349 \left[12* \left\{ 1 - \frac{310\,(305)}{350\,(299)} \right\} \right]$$

$$= 349 \left[12* \left\{ 1 - \frac{94550}{104650} \right\} \right]$$

$$= 349 \left[12* \,(1 - .90348) \right] = 349 \left[12* (.09651) \right]$$

$$= 349 \; (1.1581) = 404 \text{ operations}$$

This illustrative technique incorporates the seasonality and trend influences by computing a seasonally adjusted monthly rate of growth over the past two corresponding pairs of months. The forecast is obtained by multiplying the observed level of itinerant operations for the relevant month one year earlier by the estimated yearly rate of growth.

III. SHORT-AND LONG-RANGE FORECASTING USING REGRESSION ANALYSIS

Because of the complexity and volume of mathematical manipulations involved in econometric forecasting, computer solution is warranted and recommended. The illustrative procedure presented below will not discuss the mathematical formula for computing the various statistics essential to regression analysis; explaining and illustrating these would cover the same ground illustrated in any good econometrics text and would require an equal amount of space. Rather, it will focus on how to interpret and use these essential statistics so that the analysts will be able to construct a model, evaluate its worth and generate forecasts based on the model.

Econometric modeling may be used for short range forecasting and is widely accepted for long-range forecasts. The key to regression analysis is the construction of a formal model. The model should be based on the premise that the various measures of aviation activity (dependent variable or the variable to be forecast) are related to the level of economic activity. The model development and forecasting procedure can be described in the five basic steps shown below.

A. Data Gathering. The first step in econometric forecasting is to gather data on those variables which the analyst expects to be important in determining the past and future course of the aviation variable to be forecast. Considerable effort should be devoted to discerning which socio-economic and demographic variables significantly influence aviation activity and only these data should be collected. Sound and defensible economic and sociological hypotheses--explaining the reason(s) the forecaster expects a particular variable to be important and the manner (positively or negatively) each variable will impact on the aviation activity variable--should accompany each variable chosen for data collection.

(1) At the national level aggregate variables such as U.S. income, population, the number of student and private pilots, air fare costs, transportation costs of competing modes, etc., relate activity levels to economic conditions. Similar variables may be available for the regional, state, or airport level. At these lower levels of disaggregation additional characteristics, such as the number of based aircraft, land area, and airport quality (e.g., length of runway, existence of runway lights, average hours per day of aircraft operations), may be important considerations. Variables other than the above may be used, relevance of socioeconomic and demographic variables may be peculiar to the idiosyncrasies of the particular demographic area under consideration. Most commonly the variables to be used in forecasting are collected as a time series. Monthly or quarterly series are recommended for short-term econometric forecasting. While long-term forecasts may be generated using the latter series, they are generally obtained from data collected on an annual basis. A combination of time series and cross sectional data may also be used for forecasting.

B. Screening Process. The second step is to empirically screen the economic variables which have been selected for inclusion on theoretical grounds. This screening process consists of plotting and conducting statistical tests of the relationship of the economic variables to the aviation activity variable. The purpose of these tests is to determine whether there is any empirical relationship between the economic and the aviation variables, whether the relationship is the one hypothesized, and whether the relationship is linear or nonlinear. The correlation matrix and equation (3-1) presented below are a derivative of the model used to forecast the number of general aviation aircraft on a national level. They are intended to be illustrative of the techniques only. The following two methods should be utilized in assessing the nature of the relationship among the variables selected for inclusion on theoretical grounds.

(1) Coefficient of correlation(r)--this statistic may be thought of as the square root of the proportion of the total variation in the dependent variable that has been explained by use of the independent variable. It squared value is called the coefficient of

determination and, roughly, it tells how well the independent variable explains the movements (increases or decreases) in the dependent variable over time--the domain of this statistic is from zero to one. The higher the coefficient of correlation, the more useful the independent variable. The correlation matrix, presented below, illustrates how this statistic is used to empirically screen variables selected on theoretical grounds. The acronyms heading each column and row are defined in the key. Each cell in the correlation matrix gives the coefficient of correlation between the indicated row and column variables.

TABLE D-2: CORRELATION MATRIX

	GAAA	STD	CMP	PPDPI	LIPAC
GAAA	1.0000	0.8444	0.9959	0.9826	0.4190
STD	0.8444	1.0000	0.8375	0.8630	0.7653
CMP	0.9959	0.8375	1.0000	0.9907	0.3888
PPDPI	0.9826	0.8630	0.9907	1.0000	0.4047
LIPAC	0.4190	0.7653	0.3888	0.4047	1.0000

KEY

GAAA -- number of active general aviation aircraft
STD -- number of active student pilots
CMP -- number of civilians employed
PPDPI-- per capita personal disposal income in constant 1958 dollars
LIPAC-- plant and equipment expenditure in the aircraft industry lagged by one period

First consider the variables GAAA and CMP. The hypothesis supporting the data gathering and testing process is that the number of general aviation aircraft is likely to increase as the number of people likely to purchase aircraft increase. Thus, the relationship between the dependent variable (GAAA) and the independent variable (CMP) is expected to be positive--i.e., an increase in the dependent variable is expected to be associated with an increase in the independent variable. Table D-2 shows the correlation coefficient for the GAAA, CMP relationship to be .9959. The relatively high correlation coefficient and the positive sign (a negative sign would precede the number if an inverse relationship existed) support further consideration of this variable in the equation that will be used to forecast GA Fleet size.

(a) The correlation matrix also illustrates a very critical concept in constructing a forecasting model. That is the problem of multicolinearity. Multicolinearity means that two or more of the independent variables are highly correlated. Its most common form of manifestation is a sign reversal in the estimated (forecast) equation. That is, after the set of variables are selected, via the screening process, they will be used to form the estimating equation (see subsection C: Regression Analysis). As one output, estimating this equation (utilizing some regression technique) provides estimates of the effect of a unit change in each independent variables on the dependent variable. Obtaining signs for these independent variables which are contrary to expectations (i.e., the behavorial hypothesis) may be a result of high correlation between the independent variables in the equation. This problem may be confronted and avoided, or at least the forecaster will be aware of possible problems, with the help of the correlation matrix. For example, the above correlation matrix indicates that per capita personal disposal income is a good predictor (r = .9826) of fleet size. However, it also shows that the correlation between PPDPI and CMP is very high (r = .9907). Because of this high intercorrelation, if both of these variables were used as independent variables in the GAAA estimating equation, it is very likely that the regression program would assign one of them a negative sign. Since economic theory indicates that it is unlikely that an increase in PPDPI or CMP would imply a decrease in GAAA, such results would be unacceptable. Since CMP is more highly correlated with GAAA than PPDPI, PPDPI would tentatively be excluded from the set of variable used to forecast GAAA, and CMP would be retained. On the other hand, if forecasts of students pilots (STD) were desired, PPDPI would be retained and CMP would be excluded.

(b) It should be noted that while a high coefficient of correlation does lead to a greater feeling of security about the hypothesized relationships, a high r value is not the only goal. Where a sound theoretical reason exists for including a particular economic variable as a predictor of

the aviation variable, such variables may be included in the forecasting equation with only reasonable regard to the correlation coefficient. For example, the above correlation matrix indicates that plant and equipment expenditure (L1PAC) is reasonably influential in determining fleet size and is not so highly correlated with either PPDPI or CMP that it would result in a sign reversal. L1PAC, a surrogate measure for previous year aircraft order, is expected to reflect the positive effect on GAAA of the annual increment to the active GA fleet stemming from new aircraft. This variable is lagged one year, because it takes approximately one year to translate such orders into a finished product. Thus, L1PAC could be useful in helping to explain those movements in GAAA not accounted for by CMP, and would be included in the set of variables considered as possible predictors for GAAA.

(2) Plots. Graphing the intersection of the historical data on the aviation and economic variables over time is most useful in determining whether a nonlinear relationship is present. Further, for the most part, nonlinear relationships will not be indicated by a high coefficient of correlation. If a plot of the data reveals a nonlinear relationship exists, the estimating equation should reflect this fact (see subsection C: Regression Analysis, and its related subparts).

C. Regression Analysis. The forecaster is interested in the levels some aviation variable (dependent variable) will assume in the future. From the foregoing steps, he knows that the level of the aviation variable he wishes to forecast is caused or is at least associated with the level of other variables. In a simplistic world, this relationship would be linear; in the real world many things cause minor deviations from the straight line. Assuming that such disturbances are on balance small and generally unpredictable, the forecaster can be satisfied with coming as close as possible to the observed data points. In the two variable case, what regression analysis does for the forecaster is to compute a line (with three variables a plane; in more than three dimensions a hypersurface) which comes closer to connecting the observed data points than any other line that could be drawn.

This line, represented by an equation (the estimating equation), describes the relationship between the variable to be forecast (dependent variable) and the list of variables (derived from the preceding steps) expected to influence the past and future course of the dependent variable. There are many good regression analysis programs available from computer vendors which perform the rigorous mathematical manipulations required to produce the analytical statistics useful to evaluate the forecasting equation. While there are many complex multiple regression techniques available, by far the most widely used method is ordinary least squares. Avoiding the supporting mathematics, presented in any good econometric text, the key analytical statistics are presented below. The following equation and supporting statistics provide an example of the typical results generated by a computer regression program, and provide a focus for the discussion.

$$\text{(3-1)} \quad GAAA = -1944.33 + \underset{(39.31)}{42.40\ CMP} + \underset{(2.27)}{35.78\ LIPAC}$$

Durbin-Watson = 1.61 Corrected R-square = .99
Number of historical data observations (n) = 15

(1) The left-most number (-1944.33) is the ordinal intercept for the equation. It simply indicates the value of the dependent variables (GAAA) if all other variables assume a zero value. The second and third numbers from the left are the regression coefficients. They indicate the effect on the dependent variable of a one-unit change in the independent variable. If the historical series on fleet size were given in hundreds, employment in millions, and investment in billions of dollars, then the coefficient for CMP means that a one-million increase in civilian employment results in a 4,240 increase in GAAA. Similarly, a one-billion increase in LIPAC would result in a 3,578 increase in GAAA.

(2) The numbers in parenthesis below each regression coefficient are the t-statistics.

The t-statistic tells us whether or not the estimated coefficients are significantly different from zero. The t-statistic resulting from the regression program is relatively meaningless in and of itself. Referring to the Students' t-distribution table (generally, the two-tail test is applicable and available in many econometric text) for the appropriate degrees of freedom (number of variables less number of parameters estimated, including the constant term), a comparison value may be found. In the above example, there are 12 (15-3) degrees of freedom, and according to the t-table the .99 percent confidence value for t is 3.055, and the .95 percent confidence value is 2.179. Without regard to the sign (negative t-values accompany negative coefficients), a t-value of 39.31 for the estimated coefficient of CMP means that the estimated coefficient differs from zero at better than the 99 percent confidence level. Thus, there is only one chance in 100 that the sign of the coefficient is other than that given in the regression equation. The t-value of 2.27 for the estimated coefficient of LIPAC means that the estimated coefficient differs from zero at the .95 percent level of confidence. The 95 percent level is commonly used as the lower acceptable cut-off level in regression analysis.

(3) The R-squared (multiple coefficient of determination) indicates the proportion of total variance in the dependent variable that is explained by all the independent variables in the regression equation. In the present example, 99 percent of the variance in GAAA is explained by CMP and LIPAC. The domain of this statistic is zero to one. Further, the example presents the "corrected" R-square; that is, the R-square adjusted for the degree of freedom. The corrected R-square is more useful than the R-square unadjusted for degrees of freedom, because the former can be used to compare different versions of equations (i.e., equations with different degrees of freedom) attempting to estimate the same dependent variable. It would be misleading to compare the unadjusted R-square among equations with different degrees of freedom.

(4) The Durbin-Watson statistic tests for autocorrelation in the data. Autocorrelation means that one observation or data point tends to be correlated with the next. While some computer programs provide an option for adjusting the estimated coefficient for first order autocorrelation, some do not. If significant autocorrelation is present, the magnitude of the estimated coefficients will be distorted (generally underestimated) and the R-square cannot be believed with any degree of confidence. Tables of the Durbin-Watson statistic are available in many econometric texts. For the given number of independent variables (k = 2) in equation (3-1) and the given sample size (n = 15), there are two values in the Durbin-Watson tables, forming the lower (d_L) and upper (d_u) bound, for testing the significance levels of the computed Durbin-Watson statistic (d = 1.61). If the computed d is less than d_L, positive autocorrelation exists. If the computed d falls between d_L and d_u the test is inconclusive; that is, one simply is not sure if autocorrelation is present. If the computed d is greater than d_u, autocorrelation is not present. This test may be conducted at either the 1 percent or the 5 percent level of significance; the latter is the commonly used cut-off level. For the example above, with n=15 and k=2, the Durbin-Watson table shows d_L = .81 and d_u = 1.07 at the 1 percent level of significance. Since the computed d is 1.61, greater than the upper bound, there is no positive autocorrelation. It should be noted that for values of the computed d greater than 2, the forecaster must also test against the hypothesis of negative first-order autocorrelation. This is done by subtracting the computed d from 4 and refer to the table values of d_L and d_u as if one were testing for positive autocorrelation.

(5) Before concluding the discussion on regression analysis, it should be noted that if a plot of the data reveals a nonlinear relationship between the dependent and independent

variables, this should be accounted for in the model. A nonlinear relation may be incorporated in the model in several ways. For example, if the relationship between the dependent and an independent variable is the general form of a parabola, the forecaster feeds in the data on the dependent variables (Y) and the independent variable (X). For convenience, X may be renamed X_1 and the computer asked to generate $X2 = X_2$. The regression is then run as $Y = c+b_1X_1+b_2X_2$. All of the foregoing analysis applies to the results. If there is more than one independent variable having a nonlinear relationship with the dependent variable, the multiplicative (log-linear) form may be used. For example, the general functional form may be $Y = CX_A Q_B$ where A and B are the exponents. Taking the log of this function gives $\ln Y = \ln C + A \ln X + B \ln Q$.

Since most regression programs have the log transformation built in, there is no need to look up the logs of the historical data. The regression program, in most cases, will perform the transformation and compute the regression coefficients on the transformed variables. If the log-linear form is used, the forecaster should be aware that the estimated coefficients (A, B) are elasticities and should be interpreted as the percent change in the dependent variable resulting from a one percent change in the independent variable. Further, the forecaster should be aware that a regression line fitted to the observed data via the log form, will have the same elasticities everywhere. Since elasticities are likely to change, especially over the forecasted period, the forecaster should be aware of this peril.

D. Assumptions. Having satisfied all of the above requirements, the forecaster now has a viable model (equation) which may be used to generate forecasts of the desired aviation variable. The fourth step in the forecasting procedure involves making assumptions about the future course of the economic (independent) variables. This is a particularly sensitive part of any forecast because we do not know the future with certainty. Various Government agencies (e.g., Department of Commerce) and private forecasting services (e.g., Wharton Econometric Forecasting Associates) provide forecasts for numerous national, state, and regional socioeconomic and demographic variables. If the level of disaggregation (or for other reasons) of the independent variables is such that the

forecasts cannot be obtained in this manner, the forecaster may also draw on his own expertise (or other recognized experts in the field) for assumptions as to the future course of the independent variables.

E. Substitute. The final step in the forecasting procedure is to substitute the forecasted values of the economic variables into the forecasting equation. This is strictly an arithmetic procedure. For example, if the historical data base used to generate the regression equation extends from 1960 to 1974, the forecasted values for 1975 through the end of the forecasted period are substituted for the independent variables. The mathematical operation, as indicated by the regression equation (3-1), is performed and the result is one forecasted value for each year.